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Federal Photovoltaic Utilization Program

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Flat-Plate Photovoltaic Power Systems Handbook for Federal Agencies

E.H. Cochrane
A.C. Lawson
C.H. Savage

April 1984
Prepared for
U.S. Department of Energy
Through an Agreement with
National Aeronautics and Space Administration
by
Jet Propulsion Laboratory
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ABSTRACT

The Federal Photovoltaic Utilization Program (FPUP), sponsored by the Department of Energy, has provided an opportunity for 26 Federal agencies to install photovoltaic power systems in various types of applications and environments. As the cost of photovoltaic power is reduced, an increasing number of potential, terrestrial, photovoltaic applications become cost effective within these agencies. Certain Federal agencies have additional criteria for the use of photovoltaic power systems such as silent operation, reliable power, and independence from the limited availability of grid power of a host country.

The primary purpose of this handbook is to provide a tool for personnel in Federal agencies to evaluate the viability of potential photovoltaic applications. A second objective is to provide descriptions of various photovoltaic systems installed by different Federal agencies under the Federal Photovoltaic Utilization Program so that other agencies may consider similar applications. A third objective is to share lessons learned which are contained throughout the document to enable more effective procurement, design, installation, and operation of future photovoltaic systems. The intent of this publication is not to provide a complete handbook, but rather to provide a guide for Federal agency personnel with additional information incorporated by references.

This handbook has been organized to present the steps to be followed in selecting, procuring, and installing a photovoltaic application. It is based on lessons learned from FPUP as well as on an overview of FPUP existing applications.

ACKNOWLEDGMENT

The U.S. Department of Energy Federal Photovoltaic Utilization Program, under the direction of Mr. Michael Pulscak, Program Manager, provides for the acquisition and installation of photovoltaic systems within the various Federal agencies. This handbook has been prepared as part of this program.

CONTENTS

SECTION I

INTRODUCTION

A. BACKGROUND

Photovoltaic energy conversion has been used for a number of years to generate electricity for space applications. Recently, photovoltaic energy conversion has been increasingly used for terrestrial applications.

Photovoltaic energy is based on the photovoltaic effect that converts light directly into electrical energy. This phenomenon first was observed in the early 19th century when it was noted that electricity could be generated when light was applied to the junction of two different materials. In recent years, with a better understanding of light and semiconductor theories, high-efficiency, relatively expensive, solar cells were developed as a source of energy for space applications.

Beginning in the late 1970s, the Federal Government has provided an incentive for industry, through research and development, to reduce the cost of solar cells by more than an order of magnitude. Photovoltaic modules purchased in large quantities (groups of solar cells in an assembly) presently have a selling price of $5.00-$7.00 per watt.

The Federal Photovoltaic Utilization Program (FPUP) has provided an opportunity for 26 Federal agencies to install photovoltaic power systems in various types of applications and environments. As the cost of photovoltaic power is reduced, an increasing number of potential, terrestrial, photovoltaic applications become cost effective within these agencies. Certain Federal agencies have additional criteria for the use of photovoltaic power systems such as silent operation, reliable power, and not using the limited availability of grid power of a host country.

These applications provide an opportunity for industry to obtain experience in Federal applications and provide a unique opportunity for technology transfer within the Federal Government and industrial sectors.

B. OBJECTIVES

The primary purpose of this handbook is to provide a tool for personnel in Federal agencies to evaluate the viability of potential photovoltaic applications. A second objective is to provide descriptions of various photovoltaic systems installed by different Federal agencies under the Federal Photovoltaic Utilization Program so that other agencies may consider similar applications. A third objective is to share lessons learned which are contained throughout the document to enable more effective procurement, design, installation and operation of future photovoltaic systems. The intent of this publication is not to provide a complete handbook containing such items as tables of insolation data, but rather to provide a guide for Federal agency personnel with additional information incorporated by references.

C. HANDBOOK ORGANIZATION

This handbook has been organized to present the steps to be followed in selecting, procuring and installing a photovoltaic application. It is based on lessons learned from FPUP as well as on an overview of FPUP existing applications.

Personnel participating in FPUP, both at DOE and JPL, are desirous of the successful implementation of photovoltaic power applications within the Federal organizations. Technical assistance can be provided to these organizations in the following areas:

(1) Surveying and assessing effectiveness of potential applications.

(2) Developing rationale and justification with attendant funding requirements.

(3) Developing specifications based on knowledge of industrial capability.

(4) Developing and implementing procurement strategy.

(5) Conducting module qualification tests with use of established DOE facilities.

(6) Providing technical resource for site evaluation, system installation, acceptance test, and operational evaluation.

(7) Conducting workshops.

Assistance can be arranged by contacting the Federal Photovoltaic Utilization Program Office at the Jet Propulsion Laboratory, 4800 Oak Grove Drive, Pasadena, California 91109.

SECTION II

PHOTOVOLTAIC POWER SYSTEM TECHNOLOGY

A. BACKGROUND

Each day, the amount of sunlight that falls on Earth is equivalent to 15 years of the world's current energy consumption. The conversion of a portion of this solar radiation directly into heat or electricity is a goal of various solar technologies. Photovoltaics, the direct conversion of sunlight into electricity, has a conversion efficiency of about 10%. Solar cells are semiconductor devices that convert solar energy into electricity using the photovoltaic effect in which photons liberate charge carriers from their bound conditions within a semiconductor. In a solar cell, the junction collects the freed charge carriers and forces them through an externally connected electric load.

B. PHOTOVOLTAIC POWER SYSTEMS DESCRIPTION

The major elements of a typical photovoltaic power system for stand-alone, non-grid interactive applications are: (1) solar array, (2) a voltage regulator, (3) rechargeable batteries, and (4) inverter/converter (Figure 2-1). If the load requires alternating current (ac), an inverter is also required for converting the direct current (dc) output of the array and a converter is used to step up or down the input voltage to the load.

Graphic descriptions of the operation of a photovoltaic power system, its battery charge and discharge, are shown in Figure 2-2.

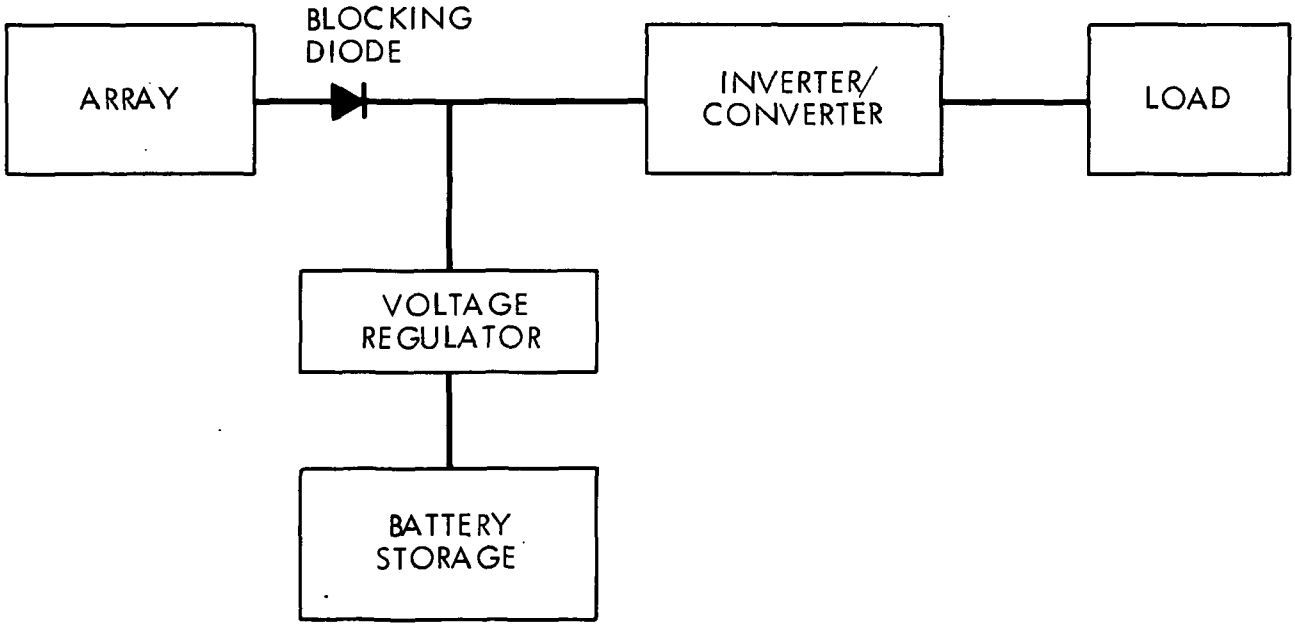


Figure 2-1. General Block Diagram of Solar Cell Array Power Subsystem

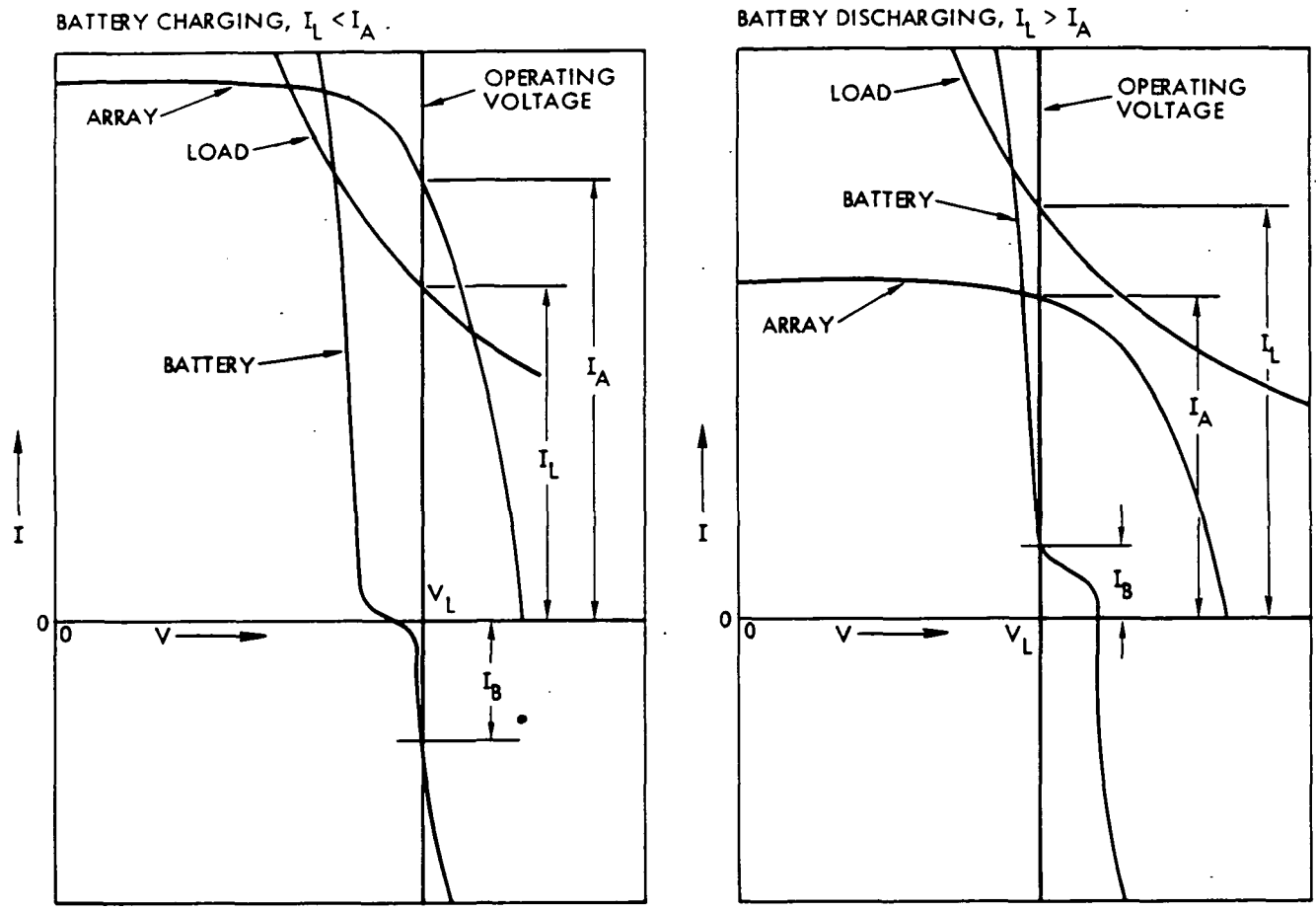


Figure 2-2. Solar Cell Array, Storage Battery, and Load Connected in Parallel (Condition I = 0 must be satisfied in all cases)

LEGEND: I_A = Available Array Current
I_B = Battery Charging Current
I_L = Load Current
V = Bus Voltage (common to array, battery)
V_L = Load Voltage

The graph depicting battery charging shows the battery being charged by the available array current, I_A, which is greater than the load current, I_L. The magnitude of the absolute battery charging current, therefore, is $I_B = I_A - I_L$.

In a battery discharge mode, however, the available array current, I_A is less than the load current, I_L. Thus, the absolute battery current $I_B = I_L - I_A$. Note that under these conditions, there is a decrease in the effective power of the solar array.

C. PHOTOVOLTAIC CELLS

Photovoltaic cells first found widespread use in space applications. These cells convert solar radiation directly into dc electricity whenever discrete

amounts of solar energy (photons) are absorbed within the semiconductor material near the p-n junction adjacent to the surface. The energy carried by a photon results in the production of positive and negative charges. Collection of the positive charges on the p-side of the junction, while the negative charges collect on the n-side, create a voltage potential across the junction.

Electrical contacts placed on the p-side and the n-side of the solar cell allow the charge generated within the cell to be used to supply power to an external load.

The current-voltage (I-V) curve of a solar cell is shown in Figure 2-3.

Many commercially available photovoltaic cells are fabricated from single-crystal silicon ingots grown from semiconductor-grade polycrystalline silicon. The finished ingot is sliced into 10 or 15-mil-thick wafers and chemically treated. The contacts are applied to wafers by various methods, including silk screening and plating, using materials such as silver, copper, and nickel. The construction of a typical solar cell is depicted in Figure 2-4.

A cell's electric current is primarily dependent on the intensity of solar radiation striking its exposed area. The voltage produced, however, primarily is dependent on a cell's temperature; an increase in temperature lowers both the output voltage and output power and reduces a cell's efficiency (see Figure 2-5).

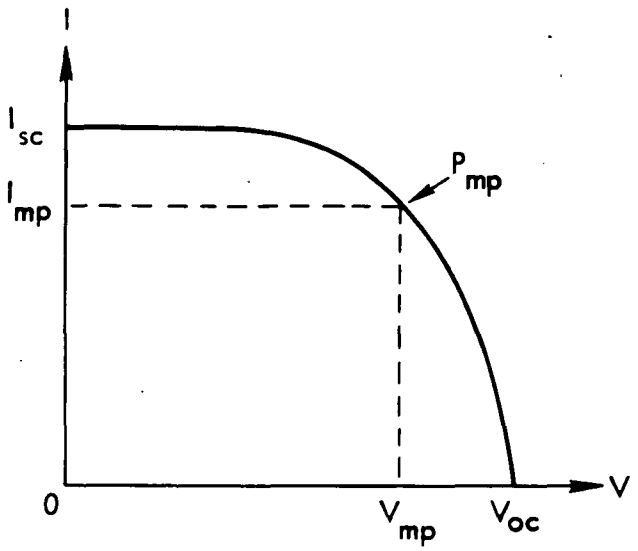


Figure 2-3. Current-Voltage (I-V) Curve of a Solar Cell

LEGEND: P_{mp} = Maximum power point
I_{mp} = Current at maximum power output
V_{mp} = Voltage at maximum power output
I_{sc} = Short circuit current (maximum cell current)
V_{oc} = Open circuit voltage (maximum cell voltage)

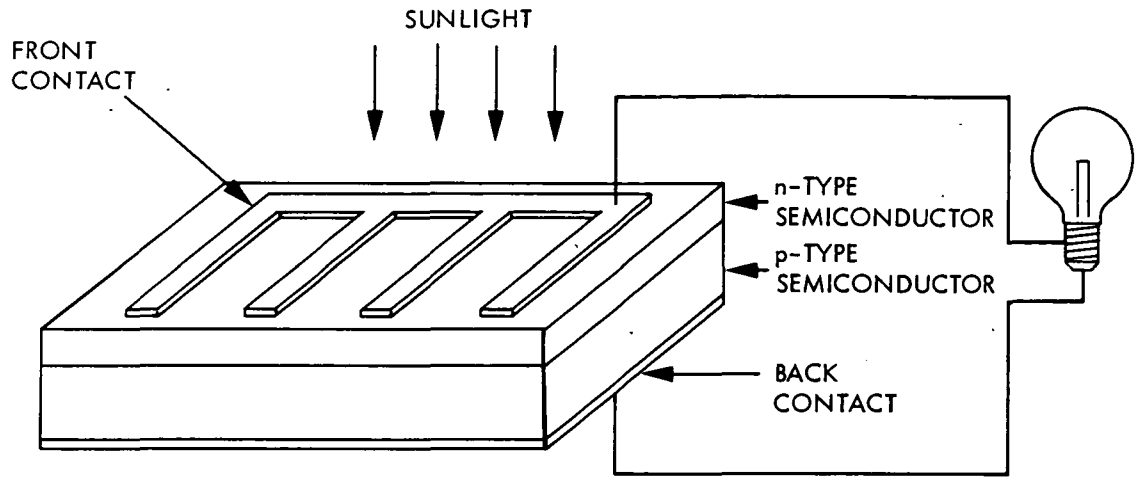


Figure 2-4. Architecture of a Typical Solar Cell

In an effort to standardize, the photovoltaic industry has adopted the following standards:

Solar radiation striking the cell = 100 mW/cm^2 = $1kW/m^2$
Cell operating temperature = 28 C (82 F) approx.

To get a desired voltage, several cells are connected in series. In turn, strings of series-connected cells are connected in parallel to generate a desired amount of current (Figure 2-6).

To provide higher voltages and currents, 30 to 40 cells similarly are connected in a series-parallel circuit configuration to form a photovoltaic module.

In turn, a photovoltaic array consists of a number of modules connected in series and in parallel and mounted within a support structure.

Other components of a photovoltaic power system are a voltage regulator that controls the output voltage from the array to maximize the charging of the battery. It also limits the loss of water that would occur from gassing of the battery if it were overcharged. At night or on cloudy days, the blocking diode prevents the electrical energy stored within the battery from discharging through the voltage regulator or the array.

Battery storage, most commonly involving a lead-acid battery, stores excess electrical energy produced by the solar array in daytime for use during the night or under cloudy conditions. Ideally, a storage battery should have long life, involve low maintenance, and must survive a number of deep discharge cycles with subsequent recharge.

To provide the load voltage, several batteries are connected in series. In turn, several of these series battery-strings are connected in parallel to provide the required load current.

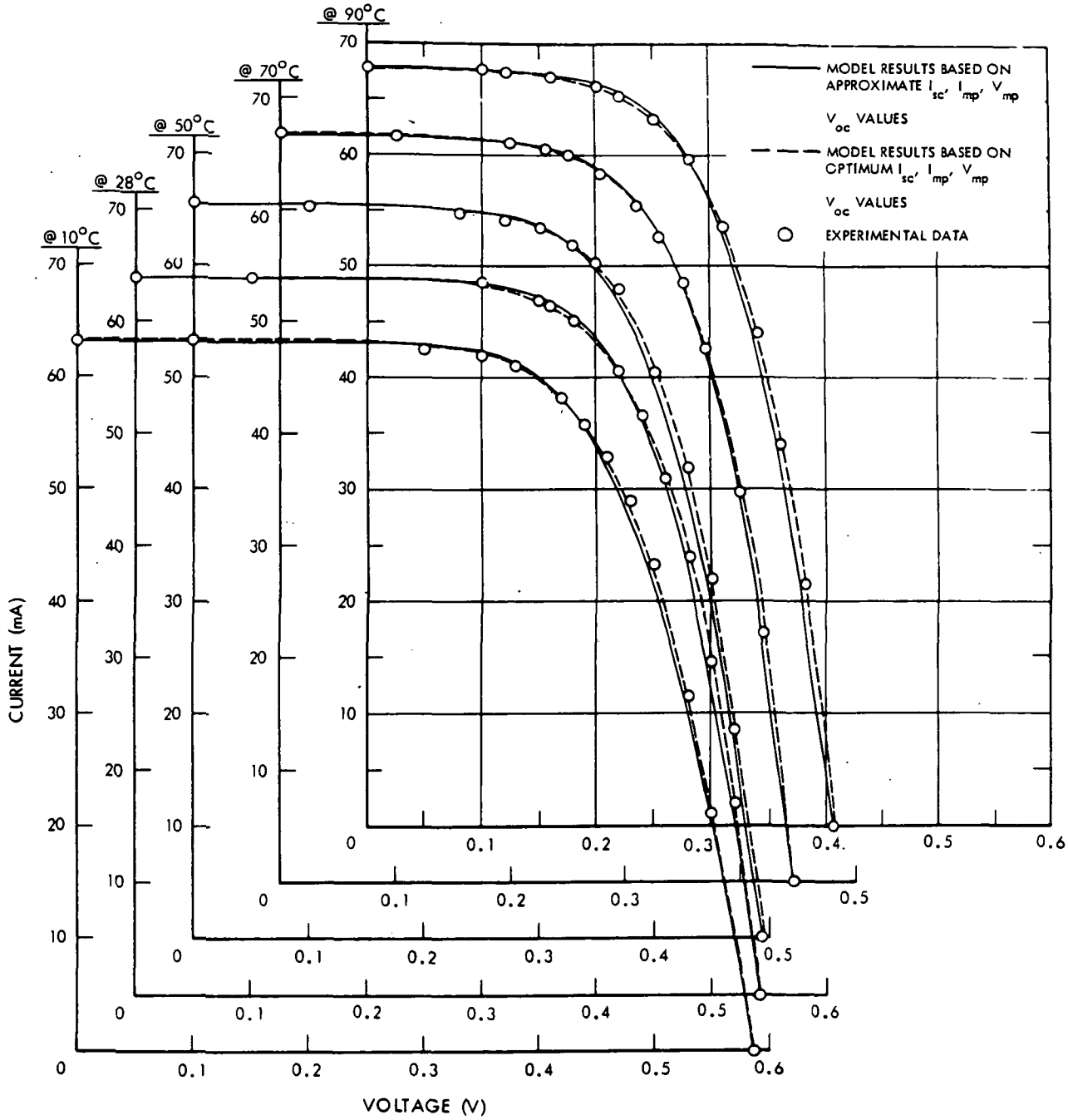


Figure 2-5. Solar Cell I-V Characteristics as a Function of Temperature (see legend, page 2-3).

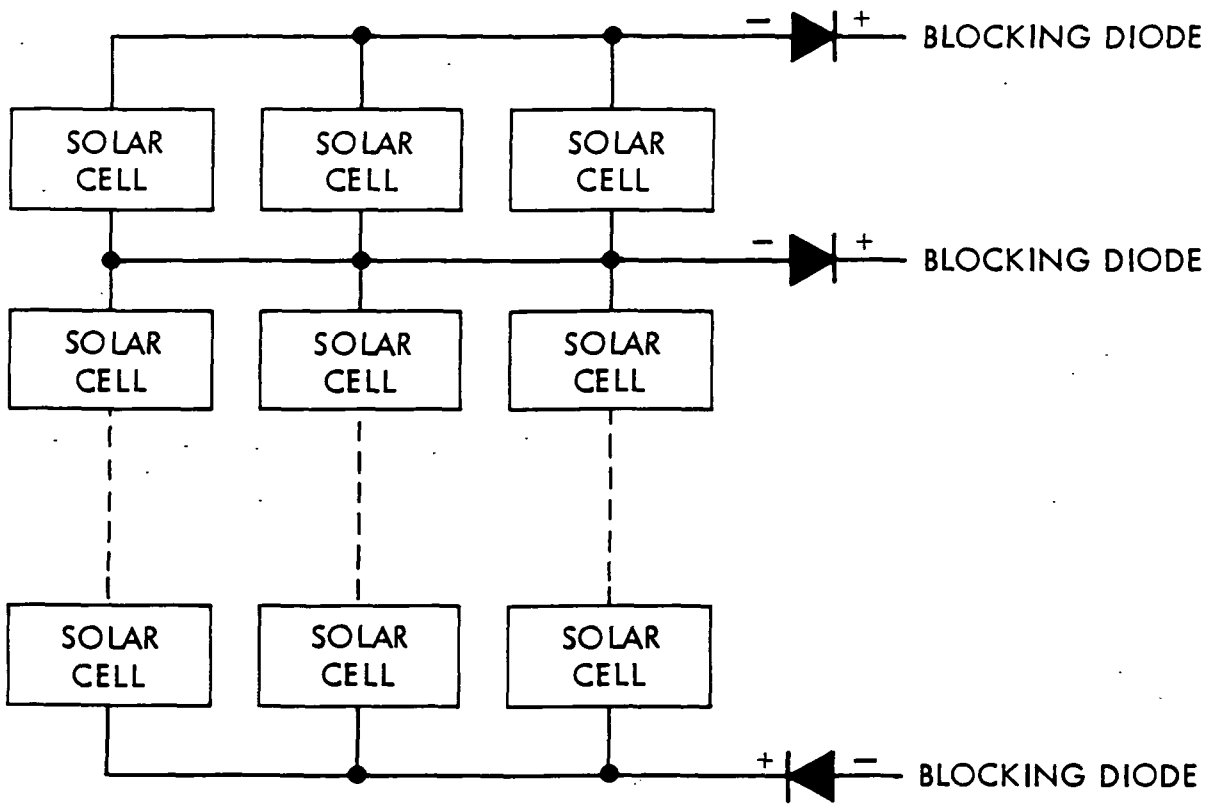
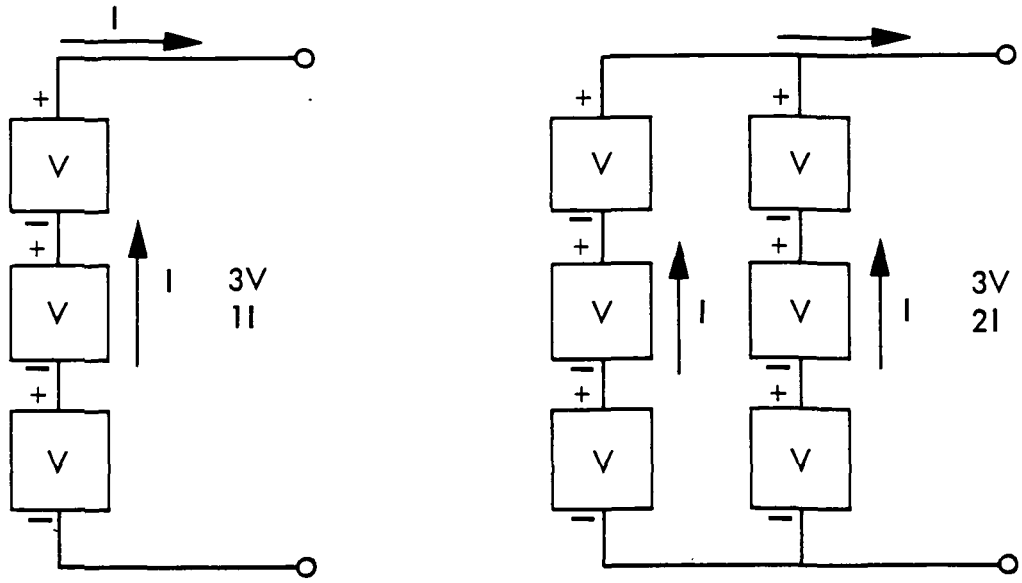


Figure 2-6. Configuration of Subgroups of Solar Cells

Figure 2-7 illustrates batteries connected in both series and series-parallel circuits. In a series circuit, the voltage of the string of batteries is equivalent to the sum of the individual battery potentials. In a parallel circuit, the total current is the sum of the individual currents in each series string, while the total voltage is the sum of the voltages in only one series string.

Some solar energy applications, such as water pumping, need only a water storage tank, a photovoltaic array and a dc water pump. But, under most circumstances, some sort of power conditioning is needed to provide the required power to the load. Lower conditioning can be as simple as a dc-to-dc converter and/or a voltage regulator, or as complex as a three-phase sine-wave inverter. In most cases, the application load determines the components necessary for proper power conditioning.



SERIES CONNECTIONS

SERIES-PARALLEL CONNECTIONS

Figure 2-7. Current and Voltage Characteristics of Series and Series-Parallel Circuits of Connected Batteries

SECTION III

SELECTION OF APPLICATIONS

A. INFORMATION REQUIRED ON CANDIDATE APPLICATIONS

The first step in the selection of photovoltaic power systems is for coordinating engineering personnel to take a survey of potential user organizations regarding their candidate photovoltaic power applications. The survey should require detailed information on the candidate applications, including the type of load, the size of load, the peak power demand, the location, the duty cycle, the current source of power (if any), the cost of this power, and relevant environmental data.

B. PRELIMINARY EVALUATION OF CANDIDATE APPLICATIONS

To make a preliminary evaluation of the candidate applications, the information from the survey should be evaluated by comparing it to a set of established criteria. As a minimum, these criteria should include:

(1) Cost-effectiveness.

(2) Suitability of the load.

(3) Site characteristics.

(4) Environment.

For certain specialized applications, other considerations might be applicable such as energy vulnerability, quietness, as well as reliability and quality of available grid power.

1. Cost-Effectiveness

A complete photovoltaic power system cost analysis should be conducted to estimate life-cycle costs in comparison with such costs for alternative systems. An introductory treatment of this subject is presented in Section IV, System Sizing and Life-Cycle Costing Methodology. A more detailed presentation is contained in Stand-Alone Flat-Plate Photovoltaic Power Systems: System Sizing and Costing Methodology, JPL Document 5260-32 (Reference 9).

2. Suitability of the Load

Power requirements for photovoltaic applications vary depending upon a number of factors, including duty cycle and peak power demand. Some duty cycles require continuous maximum power for 24 hours per day. In certain locations where insolation is marginal, the design of such a stand-alone

system necessitates the use of a very large number of storage batteries that would result in an unacceptable cost-effectiveness.

An extremely high peak power demand could influence the design of a system so strongly that cost-effectiveness of the photovoltaic system would probably be unacceptable. An example of an unsuitable load, because of extremely high peak power demand, is where most of the total load is due to air conditioning.

3. Site Characteristics

Features of the proposed site that would influence the performance of an installed photovoltaic power system are of great importance to the evaluation of a candidate application. Significant features are geographical location, nature of the terrain, vegetation and environment. Selection of a site location is extremely important because it determines the amount of solar insolation available for conversion to electricity.

Data concerning the location should also indicate the site's accessibility. This allows an assessment of the relative degree of difficulty and cost likely to be encountered in the installation of the power system. If the load is located in a building, information is needed concerning orientation of the building, the size and type of roof, as well as the availability of land within reasonable proximity. This information permits an evaluation of a roof-mounted application compared to a ground installation.

The nature of the terrain at a proposed site obviously can influence the specific location chosen for the installation of a photovoltaic system because of adverse cost implications. Solar shadowing of the photovoltaic array by prominent terrain features must be avoided. Steps to prepare the site, such as leveling the ground, removing large rocks, and cutting brush and trees must be kept to a minimum.

The terrain also affects the choice of the design of the support structure for the solar arrays. Thus, at sites where the soil is very rocky, the preparation of holes for concrete footings is extremely difficult and labor-consuming. In such a situation, the use of a structure incorporating above-ground metal troughs as the base elements of the support structure has proven to be very effective. The troughs, held in place by long stakes driven into the ground, are filled with heavy materials indigenous to the site such as rocks, gravel and sand.

Vegetation at the proposed site should be identified with respect to height and location because it may increase solar shadowing that can reduce the output of the array. In some instances, shadowing by trees and shrubs could produce hot spots in the solar array and may lead to solar module failures. Consideration should be given to the costs involved, where necessary, in cutting and removing the vegetation. In some specific areas, such as the United States National Parks, consideration must also be given to attendant aesthetic issues.

4. Environment

Environmental conditions at a site play a significant role in the evaluation of candidate applications because of their marked effect on the design and performance of a photovoltaic power system. Thus, for each site,data are required concerning temperature extremes, maximum wind velocity, rainfall, snowfall, humidity, salt spray, lightning and possible catastrophic occurrences such as earthquakes, floods, forest fires and hurricanes. Both structural and electrical aspects are sensitive to environmental conditions and require careful consideration. Stresses induced by wind, snow and ice loads, as well as temperature cycling, must be taken into account in the structural design of both the support structure and solar module. Rainfall, humidity and salt spray at a marine site require proper corrosion protection of metallic elements. Lightning protection systems are needed in area prone to thunderstorms.

Experience gained from FPUP has shown that solar modules usually survive a lightning strike on a photovoltaic system, but that the voltage regulator does not. Survival in other catastrophic events is almost impossible to ensure by standard engineering design measures.

C. SITE INSPECTION

Information submitted concerning candidate applications can be evaluated and screened to eliminate undesirable applications and to provide a preliminary selection of applications arranged in order of their desirability. Before a final selection is made, the sites for preliminary selections should be visited and inspected to amplify and verify the information submitted about the site characteristics. Observations about terrain, vegetation, and the characteristics of the roofs of buildings are of special interest.

1. Terrain and Vegetation Features

Some Federal agencies have extensive computer data banks dealing with the characteristics of their facilities. Such information is not completely suitable, however, for the evaluation of a facility for the installation of a photovoltaic power system because it often does not include pertinent information of the surrounding terrain features, nor the height and location of nearby trees and other vegetation.

2. Roof Inspection

If a proposed application is to be roof-mounted, actual inspection of the roof and attendant design documentation should be made with special attention to structural design, configuration, and the presence of traditional rooftop structures such as skylights, air conditioners, ventilators, antennas and any other items that could interfere with the installation and performance of a photovoltaic power system. The structural design of the roof should be

checked to determine whether it can support the additional weight imposed by the photovoltaic system or whether the roof requires modification to improve its support capability. Moreover, the consideration of wind loads on the photovoltaic system affecting the roof should be included.

The pitch of the roof should also be considered because it will influence the type of support structure and the mounting method required for the solar array; thus, it will affect the overall cost of the system.

D. FINAL SELECTION OF APPLICATIONS

To come up with a final selection of the photovoltaic applications that are to be implemented, it is necessary to make a complete technical assessment of those applications that previously were selected on a preliminary basis. This assessment is based on material gathered from site inspections as well as information obtained through the survey of potential user organizations. The technical assessment can eliminate certain applications from contention and may rearrange the order of desirability of the applications that do qualify. Budgetary limitations of a project must be considered before a final selection is made. The costs of photovoltaic power systems should lead to the selection of the more desirable applications within the budgetary limitations.

SECTION IV

SYSTEM SIZING AND LIFE-CYCLE COSTING

A. SYSTEM SIZING

System sizing methodologies are primarily intended for estimating the viability of a photovoltaic power system in conjunction with cost and other considerations and are not intended for use as a design tool.

The typical remote stand-alone system at Federal agencies are stand-alone systems under 15 kW, with or without the use of batteries as storage, and require either an ac or dc load potential.

The three main components of a simple photovoltaic (PV) power system are: the array, battery storage, and load. All are connected in parallel so that the voltage is common to all.

The most critical parameter in system sizing is an accurate knowledge of the load power requirements. When the load power requirements are determined, a number of system sizing and costing methodologies are available. Stand-Alone Flat-Plate Photovoltaic Power Systems: System Sizing and Costing Methodology,- JPL Document 5260-32 (Reference 9) is recommended.

B. SYSTEM COST ANALYSIS

Cost-effectiveness is a primary criterion for the economic evaluation of candidate photovoltaic applications. To determine if a photovoltaic system is cost-effective, the life-cycle cost of alternative power systems should be compared to the life-cycle cost of the photovoltaic system.

The estimated life of a diesel generating power system or extended utility grid is 25 years, while that of a battery system is 10 years. In determining the above costs, all related expenses such as operating, maintenance, replacement, and fuel storage costs should be included.

The first step in life-cycle costing is to evaluate the alternative power systems to better judge the potential savings afforded by installation of a photovoltaic power system.

Capital costs of a diesel generator and attendant fuel storage as well as operating and maintenance costs can be determined from actual costs. Note that in many remote applications, fuel delivery as well as maintenance costs can be determined from actual costs. Note that in many remote applications, fuel delivery as well as maintenance cost, including parts, labor, and transportation of a maintenance crew can be significant. Maintenance at a former diesel generator site at the 29 Palms Marine Base costs approximately $30,000 for each visit and these visits occur approximately 10 to 12 times a year. Similarly, the cost of a battery system and attendant replacement costs

can be determined from actual battery costs. The operation and maintenance costs of remote battery systems are relatively high.

The one-time capital cost of extending an existing utility grid to a remote location can be obtained from the local utility company. The operating and maintenance costs are for occasional inspection of the utility distribution line and the cost of the electricity supplied to the application.

An estimate for the extension of grid power to a west coast location is now $22,000 per mile for flat-land and is significantly higher for less hospitable terrain.

The one-time cost of a photovoltaic power system includes the initial procurement and installation costs. The one-time future cost is the battery replacement cost. Operating and maintenance costs, which include visual inspection of the photovoltaic array and maintenance of battery storage, are low and can be determined with reasonable accuracy. The unknown factors of a photovoltaic power system are the initial procurement and installation costs.

Costs of a photovoltaic system should include the initial purchase, installation, and future battery replacement costs, as well as yearly operating and maintenance costs. Estimated array life is 25 years with battery replacement every 10 years.

To determine the photovoltaic life-cycle cost, the methodology previously discussed (Reference 9) may be used.

SECTION V

PROCUREMENT STRATEGY

A. OBJECTIVE

Because each Federal agency establishes its own procurement practices and policies, which may not be similar to those of other Government organizations, the procurement strategy discussed in this section should be considered only as a guideline. No attempt will be made in this section to cover every detail of the procurement process since such coverage alone would fill a good-sized volume. Only those aspects are discussed that are based on lessons learned from FPUP experience. These can assist the cognizant engineer to avoid or, at least, to keep to a minimum those problems encountered in the procurement of a reliable photovoltaic power system.

B. COMPLETE SYSTEM PROCUREMENT

In many areas, a recommended strategy, based on FPUP experience, may be advantageous in the procurement of photovoltaic power systems. This strategy involves the procurement of a complete system from a selected system supplier who accepts the responsibility for all aspects of the system including design, fabrication, integration, site preparation, installation and testing. This approach greatly simplifies the administration of the project by the responsible Federal agency and makes the system supplier liable for demonstrating that the performance specifications are properly satisfied. Only after the system supplier demonstrates adequate system performance by means of an approved acceptance test procedure, is the title to the system passed to the Government agency. A further advantage of this strategy is that a system can be procured with a warranty provided by the supplier, without any liability to the Government, to cover any replacement, repair and rework of the system to maintain the required performance.

C. COMPETITIVE PROCUREMENT

1. Advantages

Of the several possible methods to procure a photovoltaic power system, FPUP experience has shown that the competitive method is superior. It permits the selection of a system, that most closely meets the specified requirements, from a broad range of possible designs.

Each potential system supplier submits a proposed concept to meet the specified requirements. The supplier will usually provide the system at a fixed cost and, upon satisfactory demonstration, will provide a full operational warranty for a multi-year period.

2. Contracting Officer

Each agency has its own set of procurement policies and procedures, an area in which the responsible engineer is not expected to have detailed knowledge. The importance of a good working relationship between the responsible engineer and the contracting officer assigned to the project, therefore, can not be stressed too strongly. An experienced contracting officer can provide guidance and help to the engineer at all phases of the procurement and can facilitate the total procurement process.

3. Announcement of Procurement

To publicize a procurement widely, a brief description of the procurement may be published in the Commerce Business Daily at least 20 days before the Request for Proposal (RFP) is released. This widely publicized announcement affords industry the opportunity to respond and indicate its interest in receiving a copy.

4. Request for Proposal

a. Types of RFPs. A one- or two-step procedure, involving an RFP, can be used to solicit those system suppliers who previously indicated an interest. The one-step procedure most commonly used for FPUP procurements involves the submittal and evaluation of concurrent technical, management and cost proposals. The two-step procedure, used much less frequently for FPUP, requires a separate submittal and evaluation of a technical proposal followed by a cost proposal from those companies selected on the basis of having submitted technical proposals which had been evaluated and were judged to be in the acceptable competitive range. The company submitting the lowest bid is then selected as the winning system supplier. The two-step proposal procedure is not considered as desirable as the one-step procedure because it is much more time-consuming and severely reduces the opportunity of selecting the supplier proposing a system most closely approaching the optimum design.

b. One-Step RFP. The one-step RFP requires the concurrent submittal of technical, management and cost proposals by potential system suppliers. The RFP provides information concerning the photovoltaic application and requests information in the proposals that can be evaluated against a set of criteria. An evaluation of these proposals results in a system supplier being selected. Subject to successful negotiation with a system supplier, a contract is awarded. A more detailed discussion of the proposal evaluation process and the selection of the system supplier is presented later in this section.

c. Prototype and Group Procurements. Before multiple systems of the same design are acquired, a prototype with fabricated and installed hardware is recommended for trial operation. If the system is small, the prototype should represent a complete system. For a large system, a representative segment of the

system may be used for the prototype. It is also recommended that an agency take systems with similar design and performance characteristics and group them into a common procurement package. This approach provides a more attractive opportunity for industry, reduces system costs, and promotes standardization of designs.

5. RFP Technical Proposal Preparation Requirements

a. Functional Requirements. To provide a basis for a responsive technical proposal, the responsible engineer must specify the functional requirements of the photovoltaic power system: the type of load, the size of the load, the duty cycle and the peak power requirement. He also must specify the exact geographical location of the application site in latitude and longitude, the elevation of the site, the environmental data, and the loss of probability or the number of sunless days the system must operate. If the load is housed in a building, information on building orientation and engineering drawings showing the size and type of roof should be included. If a tract of land is available near the building, information on its size and location should also be included so that consideration can be given in proposals to the options of either roof-mounting or installing the system on the ground. From the information mentioned above, a proposer can size and design a photovoltaic system.

b. System Requirements. In addition, a discussion should be requested of the approach proposed to satisfy the system requirements delineated in the RFP. As applicable to the specific function and location of the photovoltaic system, the proposal should address several or all of the following: (1) personnel safety, (2) vandalism protection, (3) intrusion detection and prevention, (4) bird deterrance, (5) mobility, (6) portability, (7) weight restriction, (8) conformance with applicable military specifications, (9) lightning protection, (10) tilt angle adjustability, (11) corrosion protection, (12) modularity of electronic components, (13) power characteristics and (14) instrumentation.

c. Hardware Qualification Requirements. Because this handbook deals with photovoltaic systems whose primary purpose is to provide a reliable power supply to applications performing necessary functions, the proposed hardware for these systems should be qualified and proven. Such a requirement should be specified in the RFP. For example, flat-plate photovoltaic modules, qualified to JPL Internal Document 5260-5 (see Reference 6), have demonstrated excellent performance in a wide variety of FPUP applications. Numerous examples of FPUP-funded photovoltaic systems that incorporate qualified components have been included in Section VII.

d. Design Review. Upon completion of the design and prior to the start of hardware procurement or fabrication, a design review should be presented by the system supplier. The request for such a design review should be specified in the RFP.

e. Module Acceptance Test. The RFP should require an acceptance test of the individual photovoltaic modules at the manufacturer's plant prior to their assembly into a system. The requesting agency should reserve the right to witness the testing which should consist of an I-V test and a visual inspection. Each module should meet the rated power output and should show no unacceptable defects. JPL Internal Document 5101-21, Revision A (see Reference 5), has proven to be an effective guide for visual inspection of modules used in many FPUP applications.

f. System Acceptance Test. Before the title to a photovoltaic system is passed to a procuring agency, a system acceptance test should be required to be performed by the system supplier at the site. This requirement should be included in the RFP. A full discussion of the system acceptance test is presented in Section VI.

g. System Performance Warranty. A system performance warranty should be specified with an effective period of at least 2 years to keep the liability of the system to the Government at a minimum. It must be emphasized that the warranty should cover the performance of the system and is not a parts-and-materials warranty. A suggested wording of the system performance warranty is as follows:

> "It is understood and agreed that the photovoltaic system will be fit for and operate in accordance within the system performance requirements specified in the contract for a period of not less than two years after acceptance by the Government. All necessary adjustments occasioned by failure not caused by misuse or accident through fault and negligence by the Government shall be made at the contractor's expense; including, without limitation: inspection by the contractor at the installation site; labor; parts; and, transportation costs, if any."

h. Training of Personnel. The proposer should be requested to respond to the requirement for a program to train agency personnel in the maintenance and operation of the photovoltaic system. The proposed program should not be highly technical or theoretical, but should be presented by a trained professional in sufficient depth to qualify personnel to operate and maintain the system properly.

i. Operation and Maintenance Manual. An Operation and Maintenance Manual should be required from the system supplier. It can serve as a basis of instruction in the training of personnel and as a reference. In the technical proposal, the bidder should discuss the general content of this manual.

j. Management Proposal. A management proposal should be requested in the RFP to be submitted concurrently with the technical and cost

proposals. It is required primarily to assess the ability of a potential system supplier to provide a reliable photovoltaic system that can supply the required power for the application equipment to function.

k. Organization. The proposer's organizational structure should be included to show the project organization for the implementation of the photovoltaic system and to indicate the relationship of this organization to the total company organization. Lines of responsibility and areas of authority should be clearly defined in the management proposal.

l. Personnel Resumes. The management proposal should also include resumes of personnel who will constitute the project team. Each resume should clearly describe the educational background and experience of a team member and the percentage of time each member will spend working on the project. In addition, any experience the company has had with similar projects should be included.

m. Project Schedule. To complete the management proposal, a detailed project schedule should be included to delineate the tasks and to identify the start and completion dates for each.

6. Cost Proposal

a. Fixed Price. Experience gained from many FPUP procurements indicates that a fixed price contract for procuring photovoltaic systems is an effective means of maintaining project cost within available funding. It is recommended, therefore, that an RFP request a proposal leading to this type of contract.

b. Cost Breakdown. Cost breakdown should be requested as applicable.

c. Caveat. In evaluating the cost proposals from competing bidders, caution should be exercised in the consideration of the lowest bidder whose cost is considerably below the range of the costs of the other bidders. Often such a bid may be an indication of the lack of understanding on the part of the bidder and requires further investigation.

d. Follow-on System Costs. If there is a possibility that a procurement of follow-on systems might occur, a request should be made in the cost proposal for system costs for a series of increasingly larger quantities over that covered by the present RFP. These might be expressed as options.

7. Proposal Evaluation

a. Evaluation Criteria. Proposal evaluation is performed by reading the various proposals submitted in response to the RFP and comparing their contents against a set of evaluation criteria. These criteria must be established by the technical manager prior to the release of the RFP. Otherwise, there may be complaints by the unsuccessful bidders that the criteria were selected after the receipt of the proposals to favor the successful system supplier. The RFP will normally include the evaluation criteria, but not the score assigned to them. The RFP will indicate the ranking of evaluation criteria in order of importance. To minimize difficulties in the evaluation process, the selected criteria should not be so limited or detailed in scope that they do not provide a useful means of selecting between the acceptable and unacceptable proposals.

b. Scoring. When the evaluation criteria have been selected, the scoring or number of possible points assigned to each criterion is decided. In the evaluation of the proposals, points are awarded commensurate to the degree to which the proposal is responsive to the RFP for each criterion. Thus, for each criterion, it is possible to award points from zero up to the maximum number of possible points assigned. Individual evaluators should evaluate and score all the proposals independently. Evaluators are then convened by the technical manager to discuss their individual scoring of the criteria and the basis of their scores. From this discussion a total score for each proposal is arrived at by consensus. These scores determine a technical/management ranking of the competing proposals by the evaluation board.

c. Evaluation Board. An evaluation board for the technical and management proposals should be composed of three to five individuals with technical backgrounds who are experienced in photovoltaic system technology as well as management of technical contracts. It would be preferable, also, if these individuals had previously been involved in proposal evaluation. In some agencies or for larger procurements, the technical and management evaluation boards may be separate.

d. Cost Proposal Evaluation. The cost proposal evaluations usually are made, as required, by the contracting officer with assistance from the cost analyst and technical manager. The evaluations consist of a comparative cost analysis to determine whether the costs and manpower proposed are necessary and reasonable to accomplish the proposed tasks.

e. Documentation. The importance of documenting the results of the evaluation board is strongly emphasized. The scoring of each criterion for each proposal and for each evaluator should be recorded systematically and retained on record. It is also desirable to retain a record of the strengths and weaknesses noted for each criterion evaluated for each proposal.

f. Clarification. During evaluation, questions on the interpretation of certain parts of a proposal may be raised. Such questions may be asked of the bidder provided they do not cover areas sufficiently extensive and significant to permit the submittal of an essentially new proposal. The bidder should make his response in writing within a stipulated time period.

8. Selection of System Suppliers

From an integration of the technical and management proposal scores with the cost proposal analysis, the technical manager and the contracting officer should rank the bidders and select the successful system supplier. The contracting officer should notify the successful bidder formally in writing and should also negotiate, with the assistance of the technical manager, any desired changes in the statement of work or cost. The negotiations may be accomplished by phone or in a meeting with the system supplier. If the negotiations are successful, a contract award should be made. In case the negotiations are unsuccessful, the second ranking bidder should be notified and negotiations initiated. Only after the contract is awarded should the unsuccessful bidders be notified that they were not selected.

SECTION VI

SYSTEM ACCEPTANCE TEST

A. PURPOSE OF SYSTEM ACCEPTANCE TEST

The system acceptance test should be a contractual requirement. It is to be performed upon completion of the installation of the photovoltaic power system to demonstrate that the total system functions properly and is designed, constructed and installed in accordance with the technical requirements of the contract between the Federal agency and the system supplier.

B. APPROACH

1. Reference Documents

For reference during the tests, it is useful to have a copy of the Statement of Work from the contract between the agency and the system supplier in which the specifications for the design, construction, installation, and performance of the photovoltaic power system are described. Further, a copy of the agency-approved Acceptance Test Plan developed by the system supplier should be required so that the tests and inspections can be performed systematically and a complete set of test data can be obtained in accordance with this plan. A schematic drawing depicting the system design, a top assembly drawing of the system and a site plan should also be required.

2. Test Roles

The responsibility for conducting the actual tests should rest with the system supplier who should provide the necessary engineering and technician personnel. The Federal agency personnel authorized to accept the system should witness all the tests, the recording of data and the inspections.

Brief descriptions of the test equipment, the test conditions, the mechanical inspection, and the electrical tests are included in this section to alert the responsible Federal agency engineer to the types of procedures that should be performed by the system supplier. All the procedures described are not always applicable to all types of photovoltaic power systems. For a dc power system, for example, the tests involving ac power are not applicable. If the agency personnel have any questions or concerns about a particular test, they should have the test repeated. The system supplier should provide all the instrumentation and tools required to perform the acceptance test as well as a form to record the test data obtained.

To avoid delays and expense, the system supplier should be encouraged to conduct the required tests on their own prior to the scheduled formal acceptance test date. In this way, any rework that might be required can be accomplished prior to the formal acceptance test.

3. Test Site

The acceptance test should be performed on the installed system at the actual application site where it will provide power to the load equipment. In this way, its performance can be accurately determined and the installation requirements verified.

4. Test Equipment

The following types of test equipment provided by the system supplier are generally required to perform the tests and inspections:

(1) Calibrated digital voltmeter (for example, Beckman Tech 310 multimeter or equivalent).

(2) Insolation meter (for example, Dodge Solar Meter, P/N 307700995-00 or equivalent).

(3) Magnetic compass with an accuracy of $\pm 2^{o}$.

(4) Measuring tape, 50-100 ft.

(5) Thermometer.

(6) Variable resistor load compatible with system receptacle.

(7) Shunt, 10 amp, 100 mV.

(8) Oscilloscope.

(9) Load of incandescent lamps.

(10) Hand tools, including screwdrivers and wrenches.

5. Test Conditions

The electrical performance tests require sufficient solar insolation for the generation of adequate power levels. It would be desirable to have the maximum insolation possible at the site for the month of the test. As a minimum, however, a uniform insolation of 50 mW/cm^2 is required.

Before the testing starts, the installed system must be turned on and the batteries fully charged.

6. Mechanical Inspection

As applicable, the photovoltaic system and the application site should be inspected to:

(1) Establish that the solar array is facing true south (in the northern hemisphere). The compass reading must be corrected by the magnetic declination for the particular site.

(2) Ensure that the array is unobstructed.

(3) Ensure that the array surface is clean and that the electrical connections between the modules are secure.

(4) Determine that the tilt angle of the array corresponds to that specified.

(5) Verify that the support structure, concrete foundations and pads are built to meet the requirements of the approved system supplier's drawings.

(6) Establish that all fasteners are securely tightened.

(7) Verify that all junction boxes, electronics boxes and the enclosed interconnections are properly secured.

(8) Verify that the battery cells are properly filled with electrolyte.

(9) Establish that any fencing around the site is securely installed and is placed in accordance with the site plan.

(10) Ensure that the components of the system are not damaged and that all workmanship is of acceptable quality.

7. Electrical Tests

a. Array Output. The following electrical tests should be performed to demonstrate that the array is performing in accordance with the specified requirements and that none of the photovoltaic modules are shorted. All tests should be made within one hour of solar noon and require a uniform insolation of 50 mW/cm^2 or greater. The insolation and ambient temperature should be measured and recorded during each test.

(1) Determine the open circuit and short circuit for each series string of the array. For some systems with internal instrumentation, these measurements can be made directly by the setting of appropriate switches. Otherwise, external instrumentation must be used. The measured values should meet the specified values and should not vary more than $\pm$10% between strings.

(2) Check the accuracy of any built-in dc meters by comparing their readings with those of a calibrated digital voltmeter for one string of the array.

(3) Demonstrate the I-V characteristics of the array by connecting a suitable dummy load in parallel to each string of the array and reading the load voltage and current.

b. System Output (dc). The following tests and calculations should be conducted to verify that the actual dc power output of the system meets or exceeds the dc output specified in the contract. All tests should be made within one hour of solar noon and require a uniform insolation greater than 50 mW/cm^2. The insolation and ambient temperature should be measured and recorded during each test. The load should be turned off so that the batteries are being charged.

(1) Measure voltage and power module current for each array string. Add the power module currents.

(2) Read the battery current and compare to the sum of power module currents. Verify that they agree within $\pm$10%.

(3) Measure the battery voltage. Verify that it falls within the specified range.

(4) Calculate the actual power output corrected to the conditions of insolation and temperature specified in the contract to verify that the actual power output meets or exceeds the specified power output.

c. Battery Voltage Regulator. To verify that the voltage regulator is operating properly, the test described here should be conducted only when the battery is near full charge and the insolation level is high. The load should be disconnected from the load to allow the batteries to charge. The battery voltage should be continuously monitored as it increases. At the overcharge potential specified in the contract, the voltage regulator should short out the array, thus preventing overcharging and boiling of the battery.

d. System Output (ac). The following measurements and observations should be made to verify the performance and ac power output of the system:

(1) Measure the ac voltage of the power output from the inverter with the internal taps of the inverter set to the desired levels to verify that the voltage is within the specified voltage range.

(2) Observe whether the inverter run-time meter is operating.

(3) Determine the ac power supply to the load. With the actual application load connected to the power system, measure the ac voltage and current and calculate the ac power.

e. Harmonic Distortion. In some applications, the level of harmonic distortion is extremely critical and, therefore, the permissible level should be specified in the contract. When this requirement is placed on a photovoltaic power system, the measurement of this characteristic must be made as part of the acceptance test. With an oscilloscope connected to the ac ouput terminals of the load distribution box and the load turned off, the sine wave pattern should be examined for any indications of distortion. With the load turned on, a similar examination for distortion should be made.

f. Voltage Ripple in the dc Power Output. From an examination of the oscilloscope pattern obtained with the dc load turned on, the dc output voltage ripple can be measured. This measurement will verify whether the voltage ripple is less than the specified limit expressed in terms of a percentage of the output voltage, as measured from peak-to-peak of the ripple.

8. Acceptance

After the acceptance test has verified that the design and the system performance meet or exceed the requirements specified in the contract, the system should be operated and monitored continuously for a period of 10 days or longer to demonstrate its continuous performance capability. Only after this period has been successfully completed should the authorized agency representative take title to the system for the Government.

SECTION VII

DESCRIPTIONS OF SELECTED APPLICATIONS

This section presents brief descriptions and photographs of some selected and representative photovoltaic applications. They have been funded by the U.S. Department of Energy and implemented by various Federal agencies as part of the Federal Photovoltaic Utilization Program.

The selected photovoltaic applications are broadly diverse, including environmental stations, mobile systems, navigational aids, pumps, radio communication systems, and residences and buildings.

If the designs of these photovoltaic systems are Government property, they are available at no cost to Federal agencies for future applications. If the designs are not Government-owned, the systems should be available from system suppliers.

The names of the Federal agency personnel responsible for these diverse photovoltaic systems are included in these descriptions. Inquiries concerning these systems may be directed to them.

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ENVIRONMENTAL STATIONS

METEOROLOGICAL DATA BUOY 0.01 kWp
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION

APPLICATION TITLE Meteorological Data Buoy

APPLICATION LOCATION Gulf of Mexico TYPE Weather Station

AGENCY DOC/National Oceanic and Atmospheric Administration CONTACT Robert Erickson

RATED POWER 0.010 kWp DC X AC _____

MODULES 2 (20V, 20 Wp) 2 (40V, 40 Wp) BATTERIES 20 (6 V, 100 Ah)

PRESENT USE Weather data gathering

POTENTIAL USE Intrusion detection, cathodic protection

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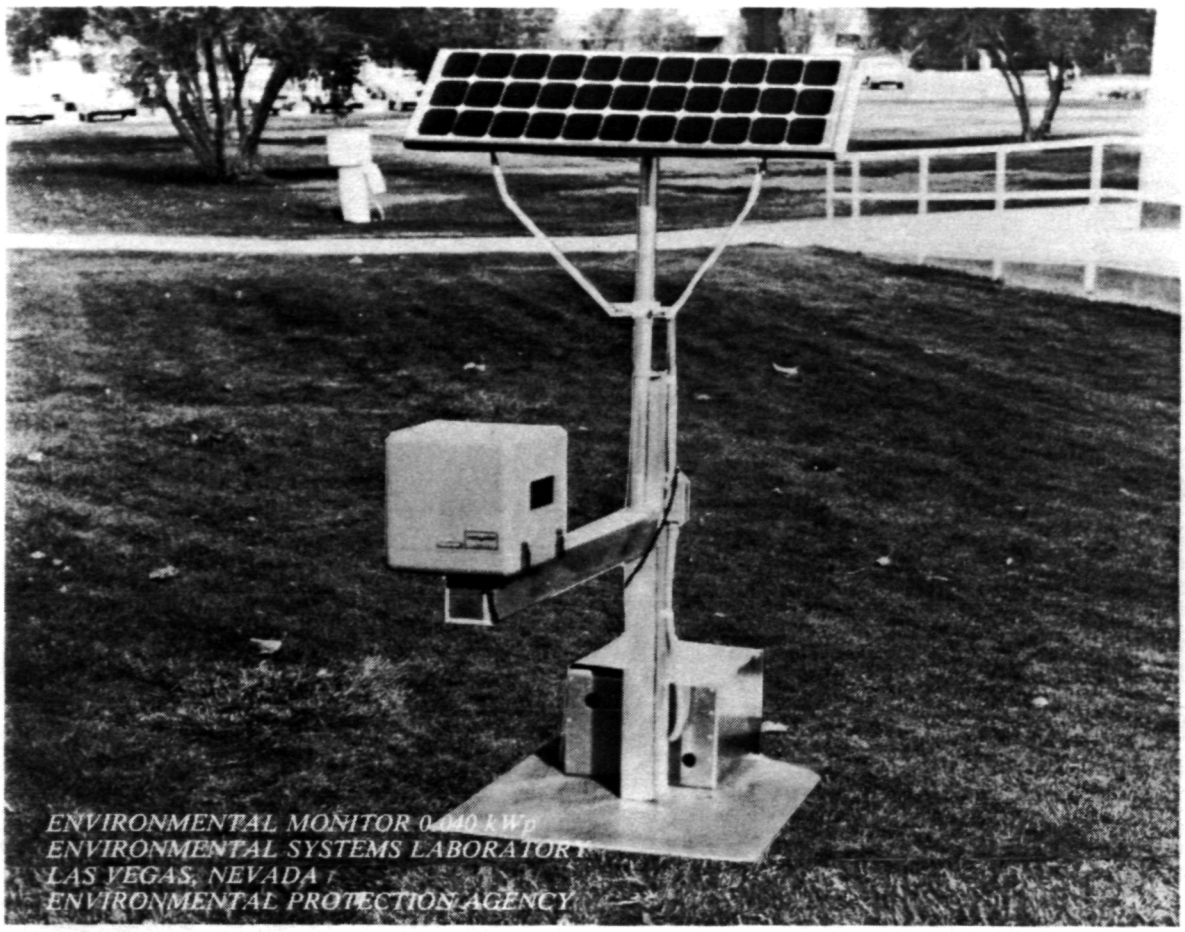


APPLICATION TITLE Radiation Monitor

APPLICATION LOCATION Las Vegas, NV TYPE Environmental Monitor

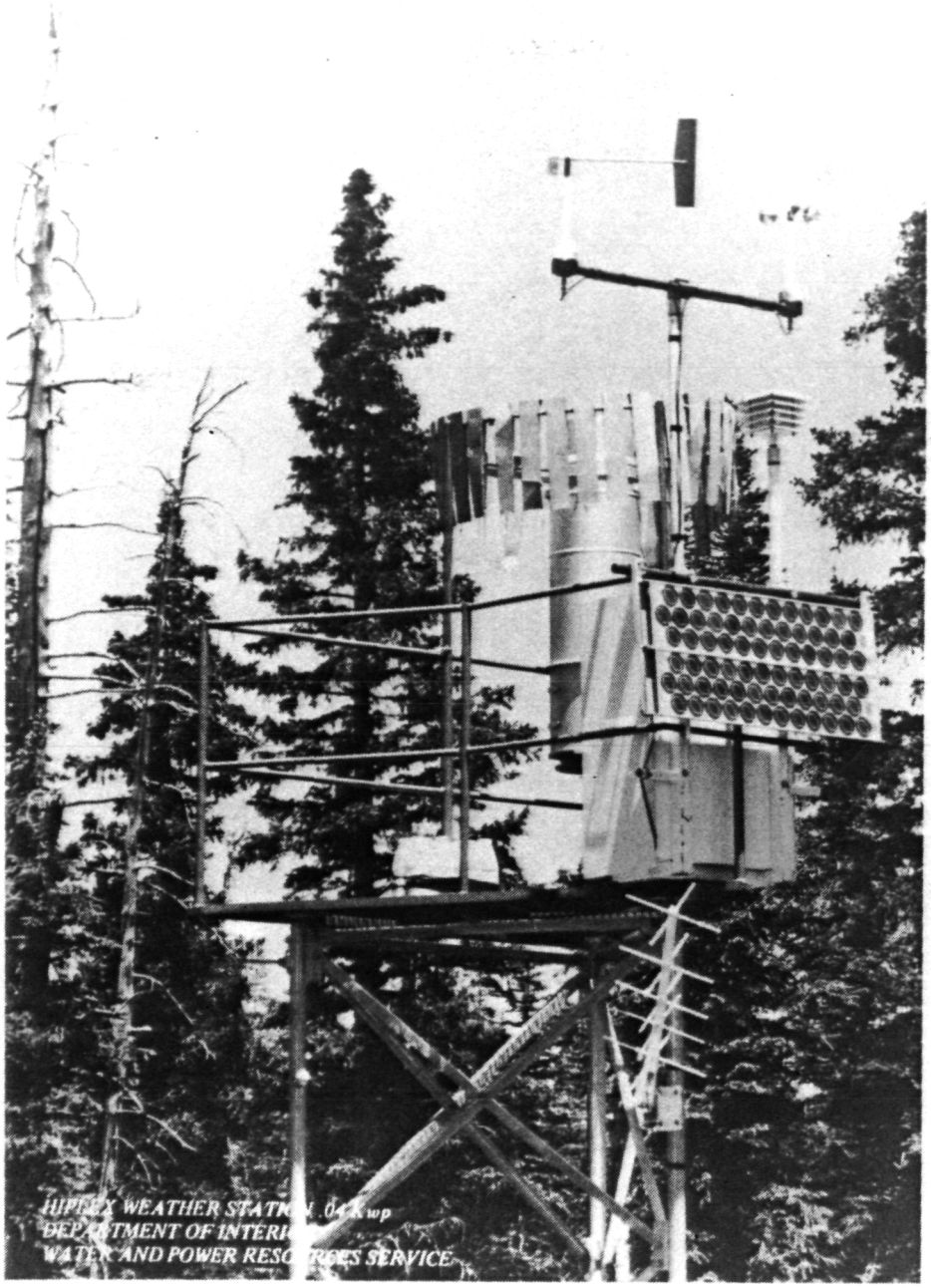
AGENCY Environmental Protection Agency CONTACT Jeff Van Ee

RATED POWER 0.040 kWp DC X AC _____

MODULES 1 (19.5V, 40 Wp) BATTERIES 1 (12 V, 40 Ah)

PRESENT USE Instrumentation to measure radiation in atmosphere

POTENTIAL USE Cathodic Protection, intrusion detection



APPLICATION TITLE Automated Hiplex Weather Station

APPLICATION LOCATION Various Western States TYPE Weather Station

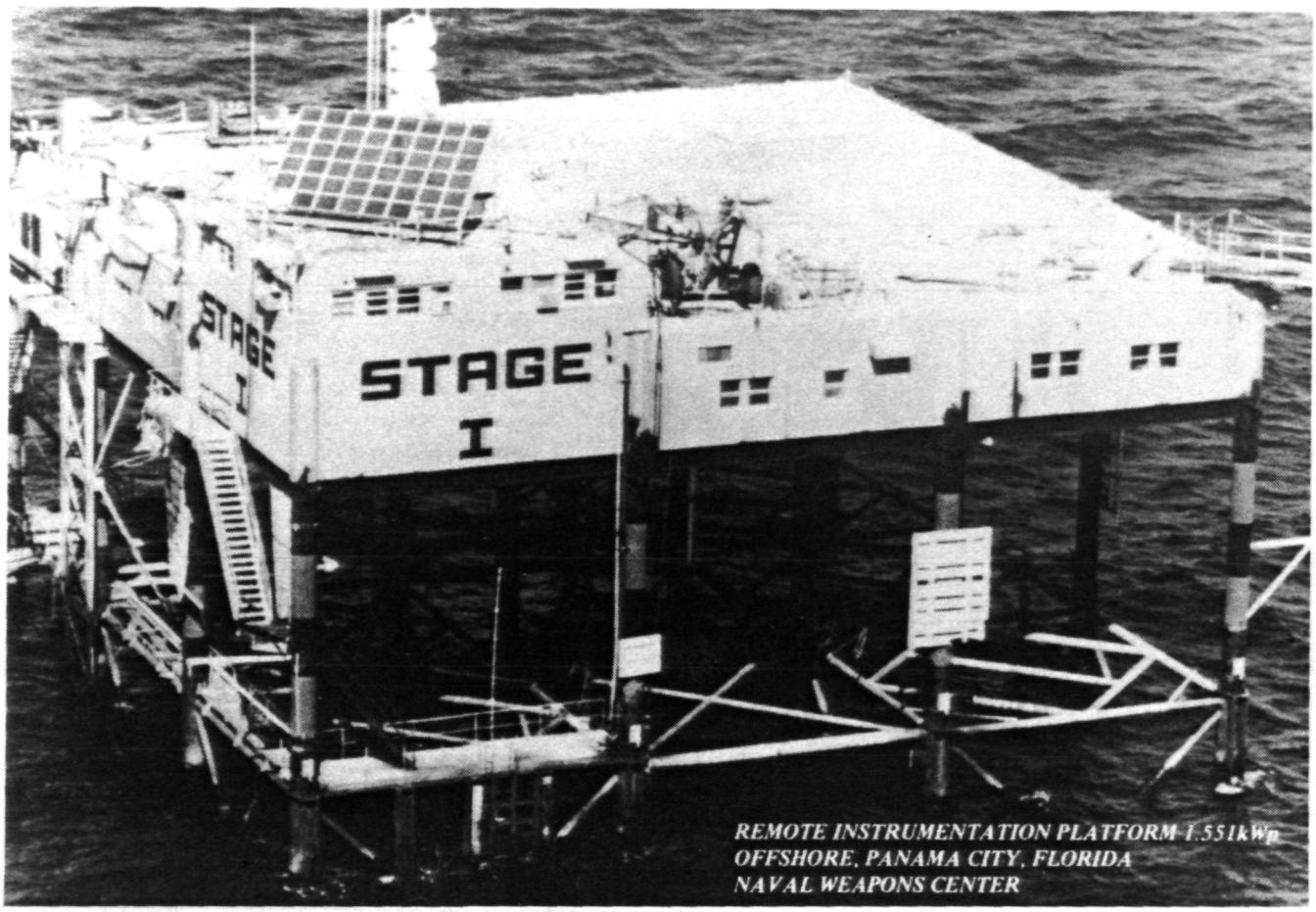
AGENCY DOI/Bureau of Reclamation CONTACT William Harrison

RATED POWER 0.040 kWp DC X AC _____

MODULES 2 (19 V, 30 Wp) BATTERIES 1 (12 V, 1150 Ah)

PRESENT USE Weather data gathering

POTENTIAL USE Beacon, lighting



REMOTE INSTRUMENTATION PLATFORM 1.551kWp
OFFSHORE, PANAMA CITY, FLORIDA
NAVAL WEAPONS CENTER

APPLICATION TITLE Instrumentation Platform

APPLICATION LOCATION Offshore, Panama City, FL TYPE Weather Station

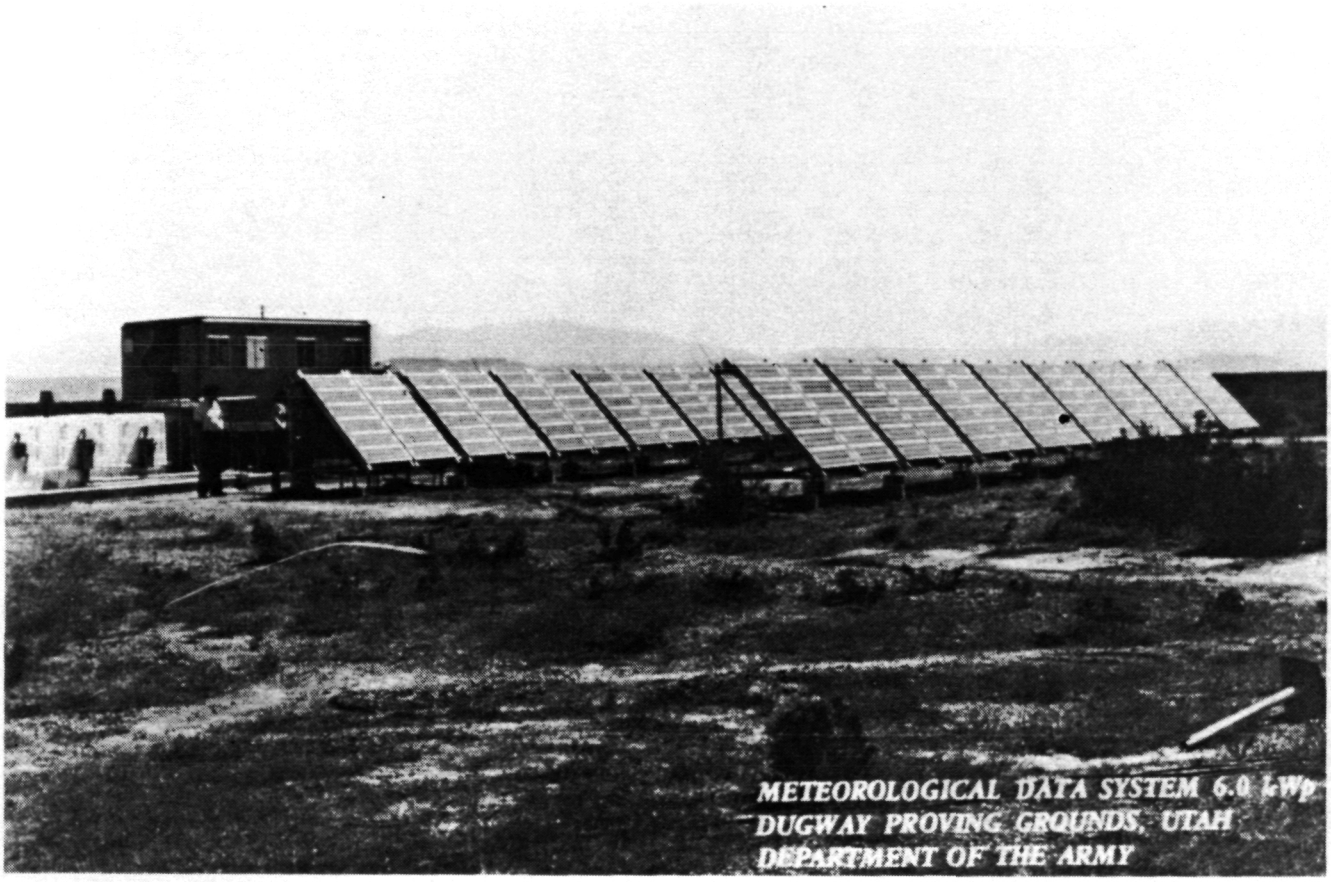
AGENCY DOD/U.S. Navy CONTACT Garyl Smith

RATED POWER 1.55 kWp DC X AC _____

MODULES 47 (15 V, 33 Wp) BATTERIES 30 (2 V, 500 Ah)

PRESENT USE Instrumentation for weather and sea-state data gathering

POTENTIAL USE Radio communication, navigational aid



APPLICATION TITLE Meteorological Data System

APPLICATION LOCATION Dugway Proving Ground TYPE Weather Station

AGENCY DOD/U.S. Army CONTACT Sam Cerami

RATED POWER 6.0 kWp DC _____ AC X

MODULES 180 (15 V, 37 Wp) BATTERIES 9 (36 V, 1160 Ah)

PRESENT USE Weather data gathering

POTENTIAL USE Residence, water pumping, microwave repeater

MOBILE SYSTEMS

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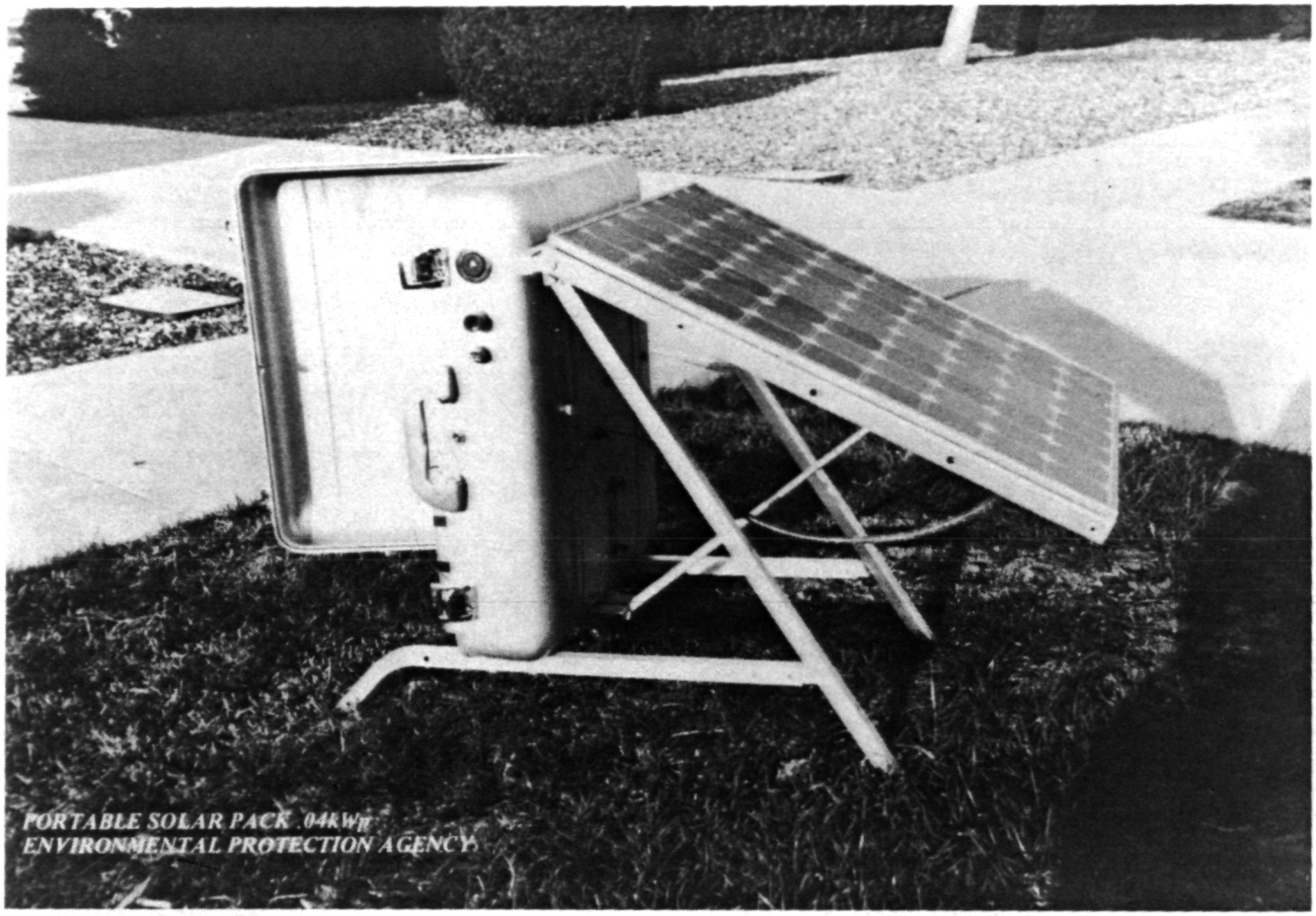


APPLICATION TITLE Particulate Sampler (Back-pack)

APPLICATION LOCATION Various TYPE Meteorological Sensor

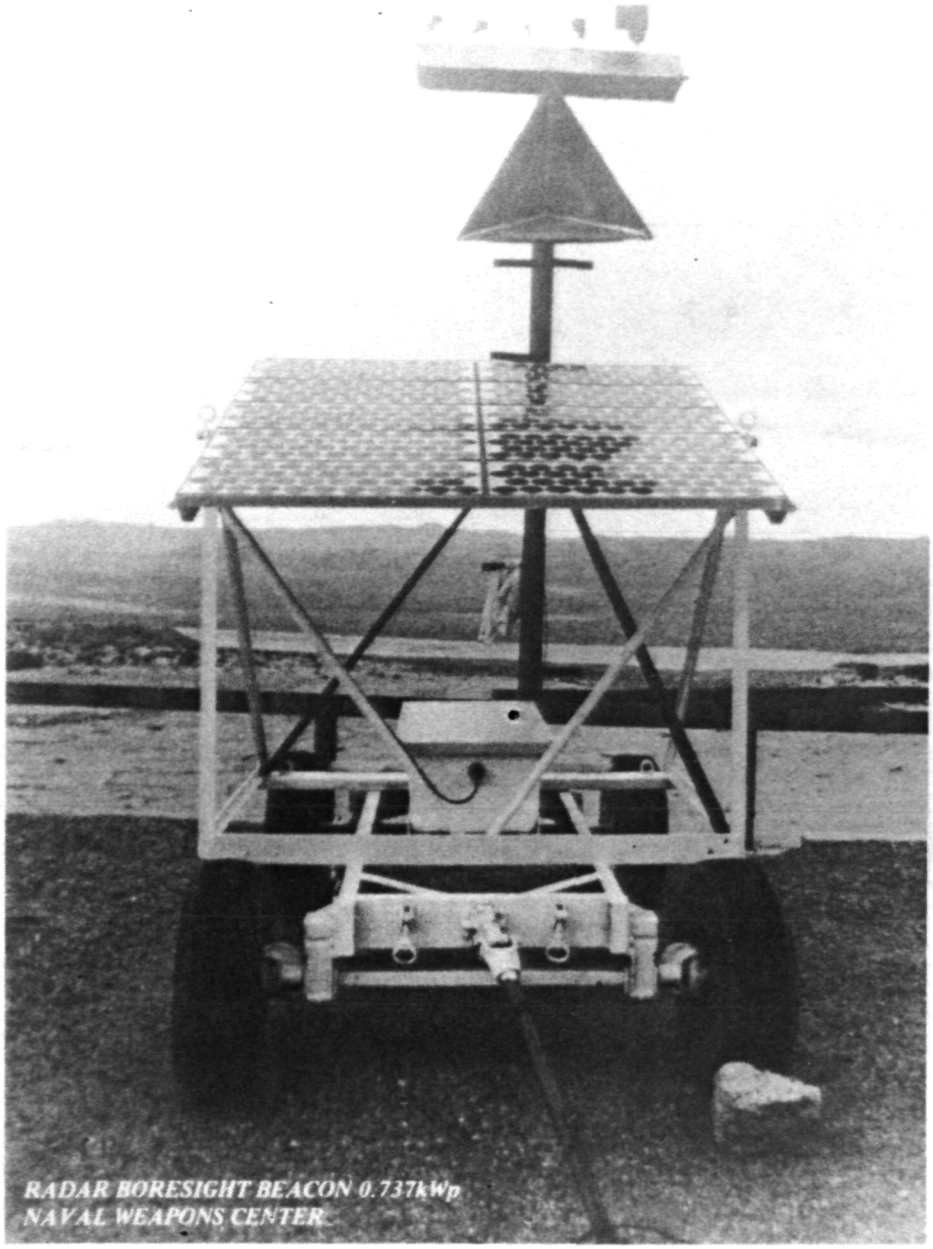
AGENCY Environmental Protection Agency CONTACT Jeff Van Ee

RATED POWER 0.040 kWp DC X AC _____

MODULES 1 (14 V, 40 Wp) BATTERIES 1 (12 V, 26 Ah)

PRESENT USE Monitor visibility, ozone, weather, and collection of airborne particles

POTENTIAL USE Portable radio communication



APPLICATION TITLE Radar Boresight Beacon

APPLICATION LOCATION Naval Weapons Center, CA TYPE Beacon

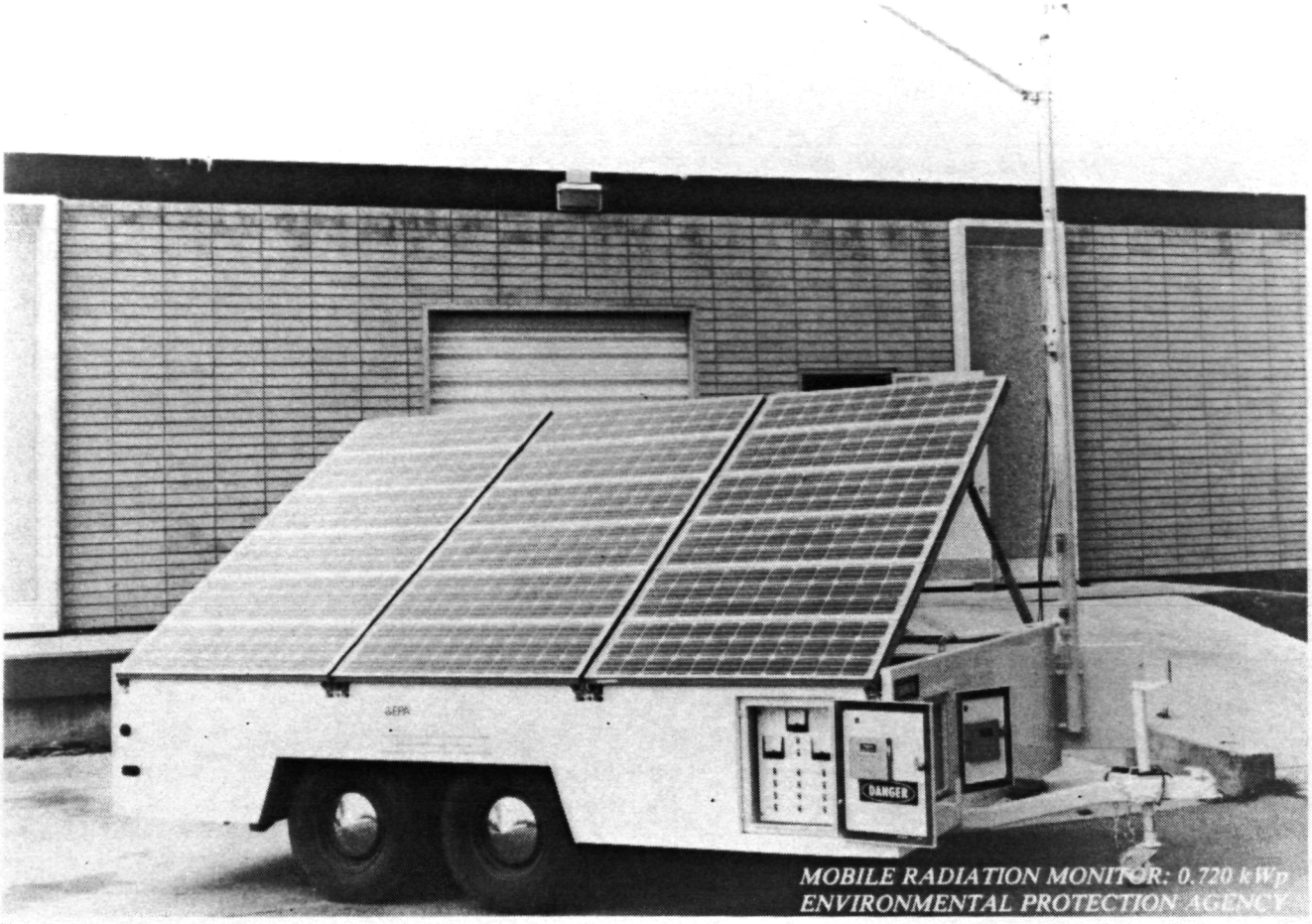
AGENCY DOD/U.S. Navy CONTACT Garyl Smith

RATED POWER 0.185 kWp DC X AC _____

MODULES 10 (28 V, 18 Wp) BATTERIES 2 (2 V, 200 Ah)
4 (6 V, 200 Ah)

PRESENT USE Calibration of radar

POTENTIAL USE Radio communication, lighting



MOBILE RADIATION MONITOR: 0.720 kWp
ENVIRONMENTAL PROTECTION AGENCY

APPLICATION TITLE Radiation Sampler (Trailer-Mounted)

APPLICATION LOCATION Various United States TYPE Environmental Monitor

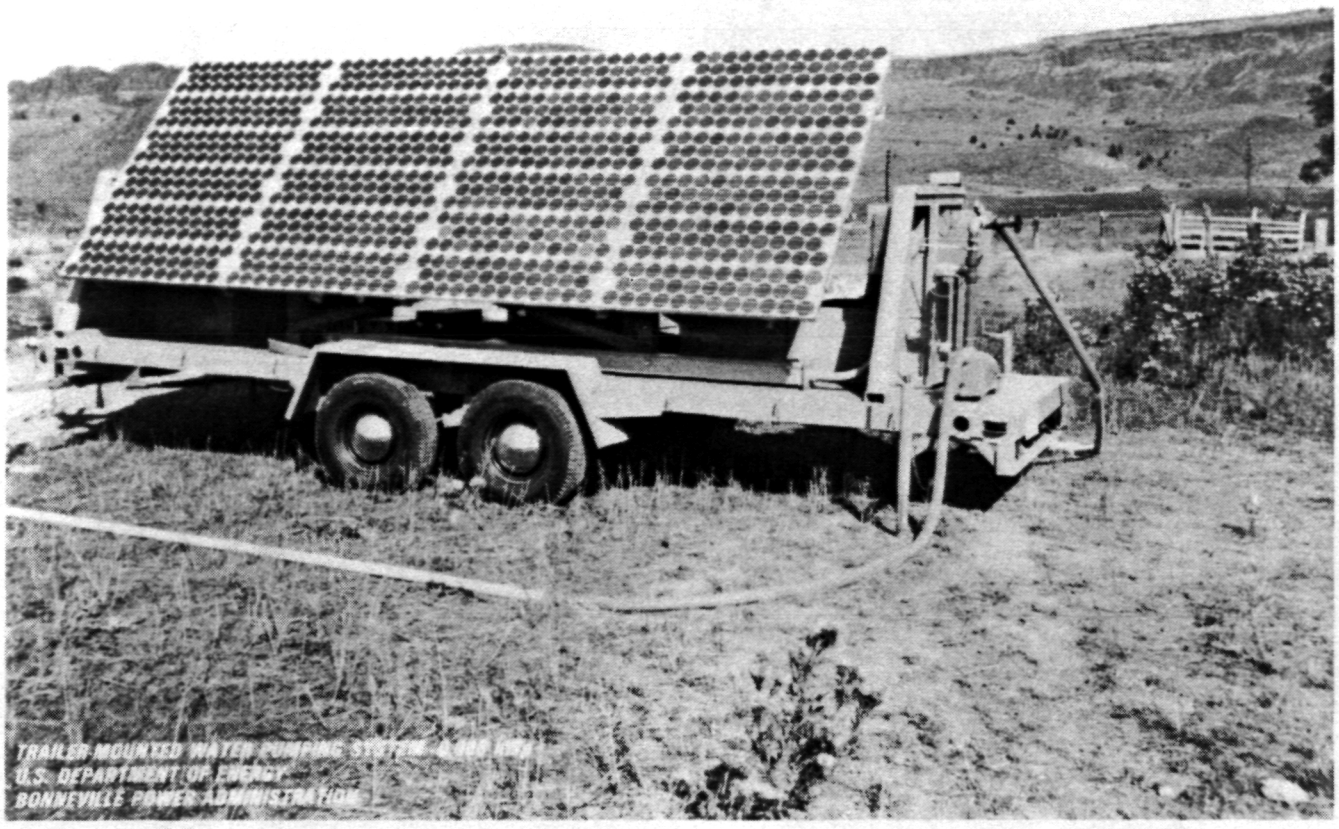
AGENCY Environmental Protection Agency CONTACT Dr. Jon Broadway

RATED POWER 0.720 kWp DC X AC X

MODULES 18 (18 V, 40 Wp) BATTERIES 40 (1.2 V, 250 Ah)

PRESENT USE Ionization chamber, radiation spectrometry, particulate air sampler

POTENTIAL USE Mobile medical unit, disaster communication center



APPLICATION TITLE Mobile Water Pump (Trailer Mounted)

APPLICATION LOCATION Various, Pacific Northwest TYPE Water pump

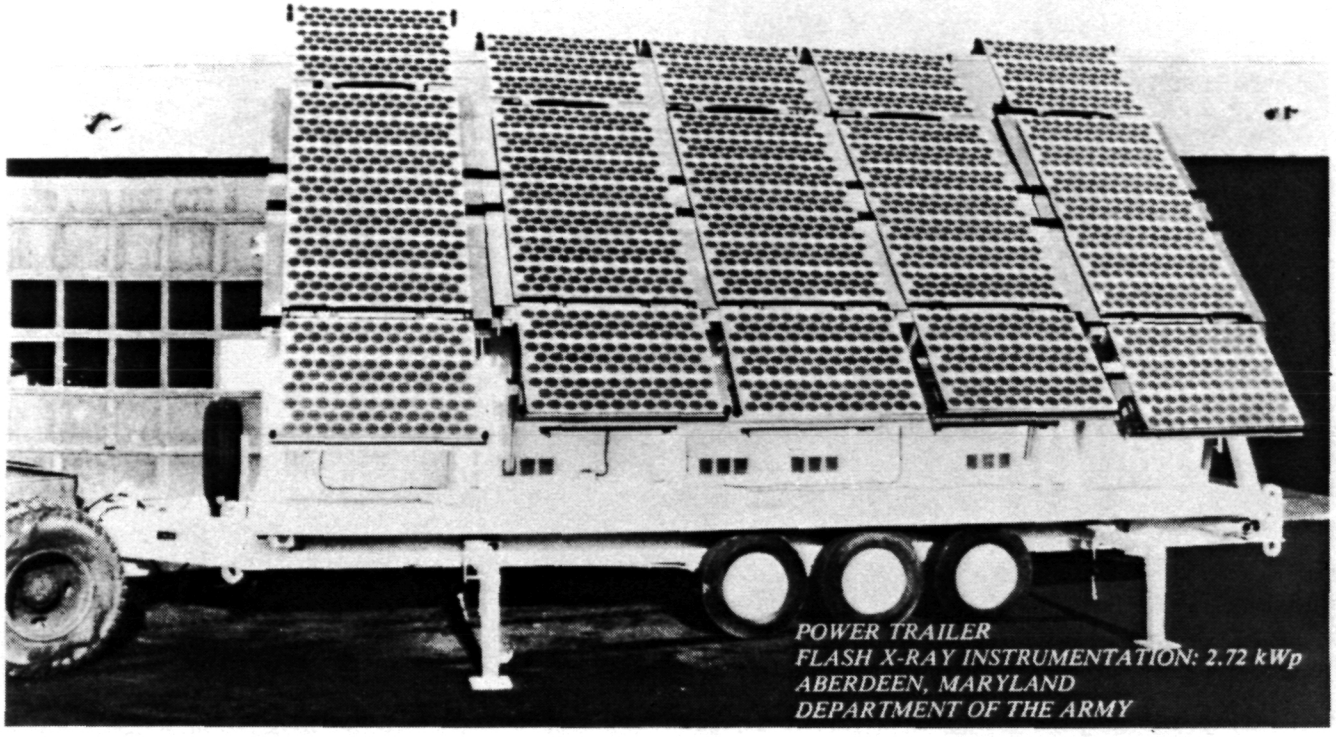
AGENCY DOE/Bonneville Power Administration CONTACT Minje Ghim

RATED POWER 0.888 kWp DC X AC X

MODULES 24 (36 V, 37 Wp) BATTERIES 12 (2 V, 250 Ah)

PRESENT USE Water pumping, demonstration

POTENTIAL USE Mobile medical and work unit, radio communication center



POWER TRAILER
FLASH X-RAY INSTRUMENTATION: 2.72 kWp
ABERDEEN, MARYLAND
DEPARTMENT OF THE ARMY

APPLICATION TITLE Power Trailer

APPLICATION LOCATION Aberdeen Proving Ground, MD TYPE Instrumentation

AGENCY DOD/U.S. Army CONTACT _____

RATED POWER 2.72 kWp DC _____ AC X

MODULES 65 (17.3 V, 42 Wp) BATTERIES 54 (13.2 V, 270 Ah)

PRESENT USE Flash X-ray equipment

POTENTIAL USE Mobile communications center

NAVIGATIONAL AIDS

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AIRPORT MOVING TARGET RADAR 3 Wp, 6 V
McCLELLAN AFB, SACRAMENTO, CAL.

APPLICATION TITLE Moving Target Indicator

APPLICATION LOCATION McClellan AFB TYPE Radar marker

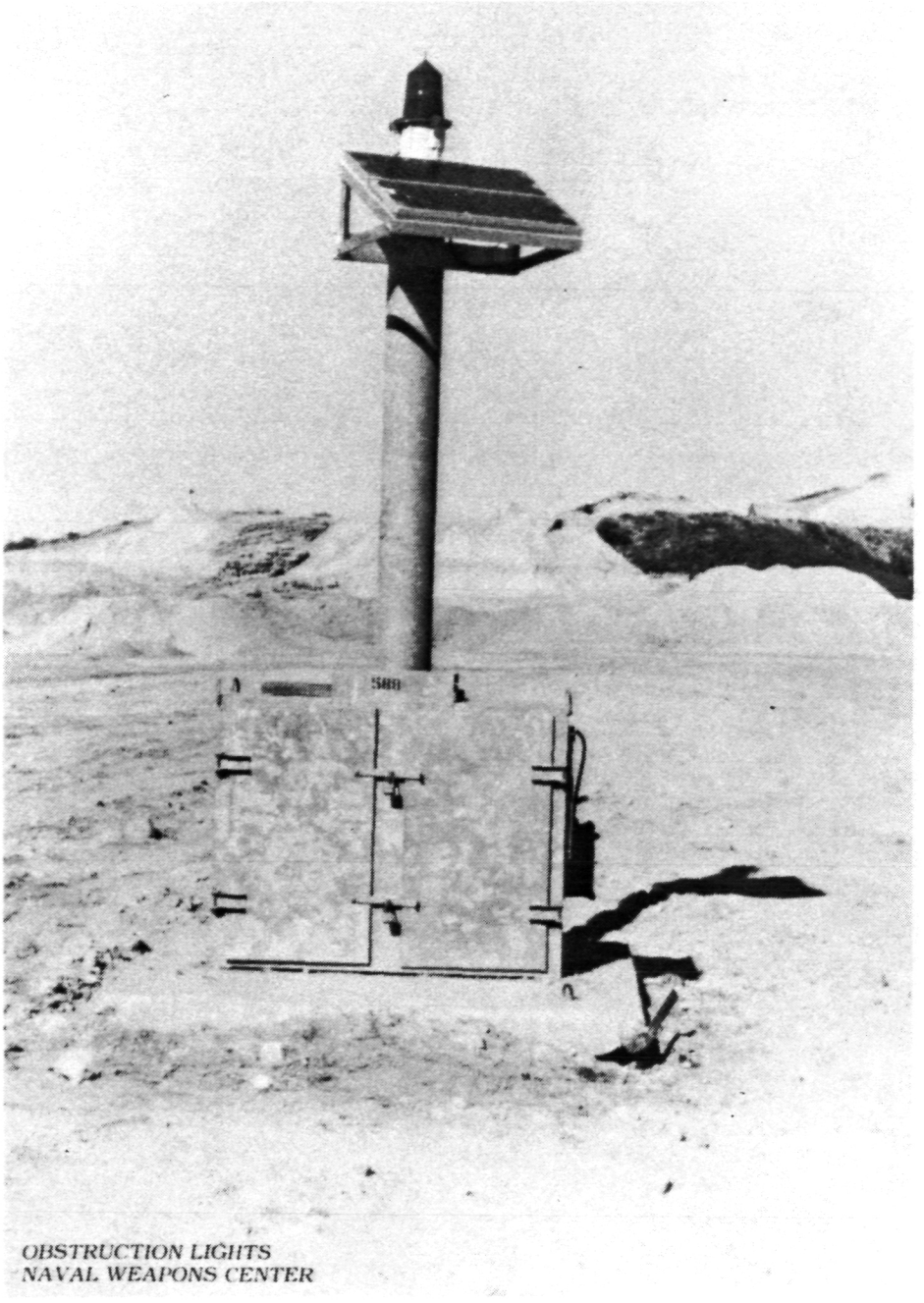
AGENCY DOT/Federal Aviation Administration CONTACT John Williams

RATED POWER 0.003 kWp DC X AC _____

MODULES 1 (6 V, 3 Wp) BATTERIES 1 (6 V, 10 Ah)

PRESENT USE Tool for adjusting maps on air traffic control radar

POTENTIAL USE Cathodic protection



OBSTRUCTION LIGHTS
NAVAL WEAPONS CENTER

APPLICATION TITLE Obstruction Warning Light

APPLICATION LOCATION U.S. Marine Air Station, El Toro, CA TYPE Beacon

AGENCY DOD/U.S. Navy CONTACT Garyl Smith

RATED POWER 0.05 kWp DC X AC _____

MODULES 2 (12 V, 28 Wp) BATTERIES 2 (6 V, 600 Ah)

PRESENT USE Warns aircraft of hills adjacent to air strip

POTENTIAL USE Radio communication, intrusion detection

APPLICATION TITLE Sand Key Reef Light

APPLICATION LOCATION Sand Key, FL TYPE Beacon

AGENCY DOT/U.S. Coast Guard CONTACT LTJG Steve Penn

RATED POWER 0.300 kWp DC X AC _____

MODULES 10 (18 V, 30 Wp) BATTERIES 20 (2 V, 500 Ah)

PRESENT USE Navigational aid

POTENTIAL USE Radio communication

WOOD END LIGHTHOUSE 0.360 kW$_p$
PROVINCETOWN, MASSACHUSETTS
U.S. COAST GUARD

APPLICATION TITLE Woods End Light

APPLICATION LOCATION Woods End, MA TYPE Beacon

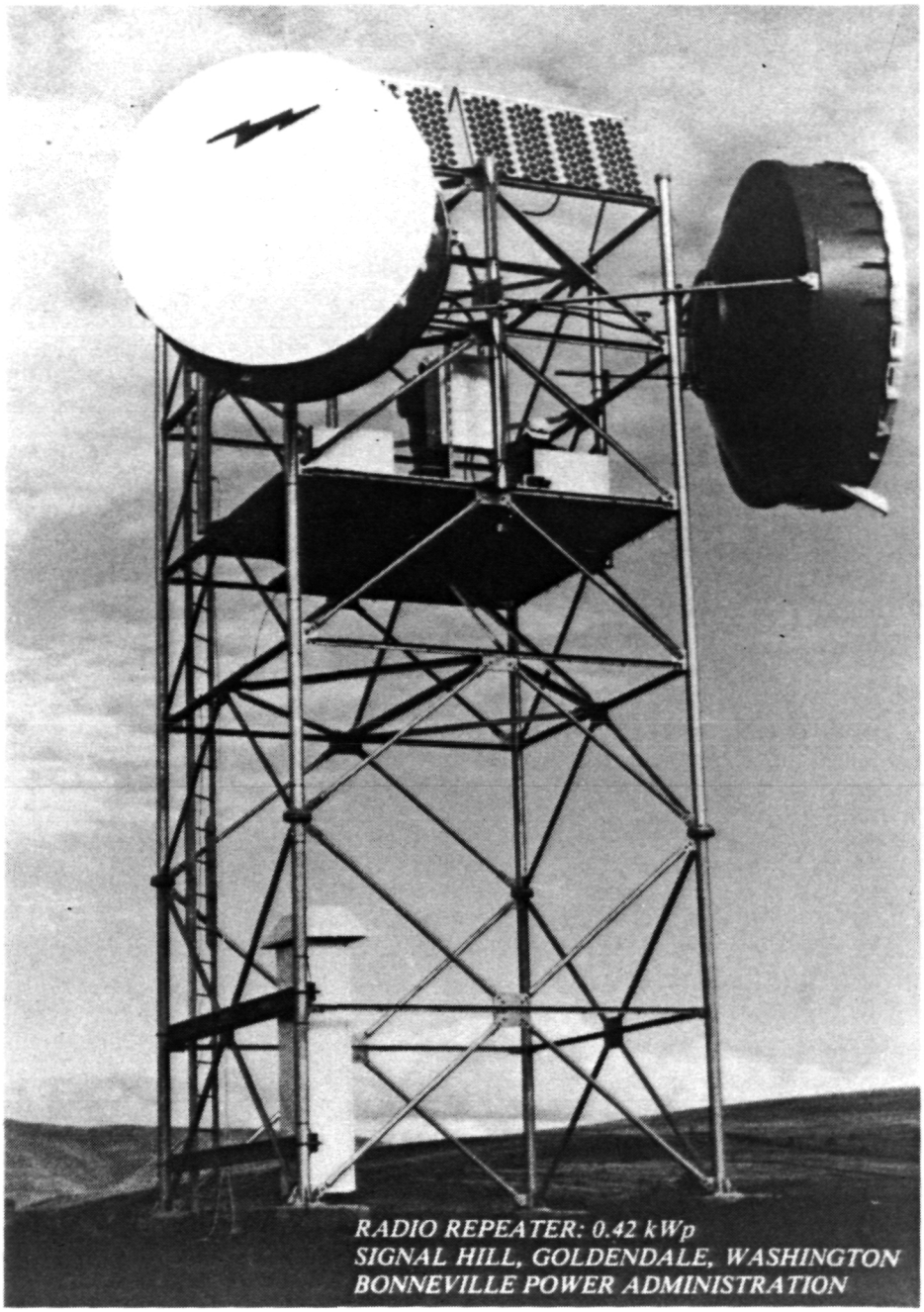
AGENCY DOT/U.S. Coast Guard CONTACT LTJG Steve Penn

RATED POWER 0.360 kWp DC X AC _____

MODULES 12 (18 V, 30 Wp) BATTERIES 20 (2 V, 500 Ah)

PRESENT USE Navigational aid

POTENTIAL USE Radio Communication



RADIO REPEATER: 0.42 kWp
SIGNAL HILL, GOLDENDALE, WASHINGTON
BONNEVILLE POWER ADMINISTRATION

APPLICATION TITLE Signal Hill Radio Repeater

APPLICATION LOCATION The Dalles, OR TYPE Radio Communications

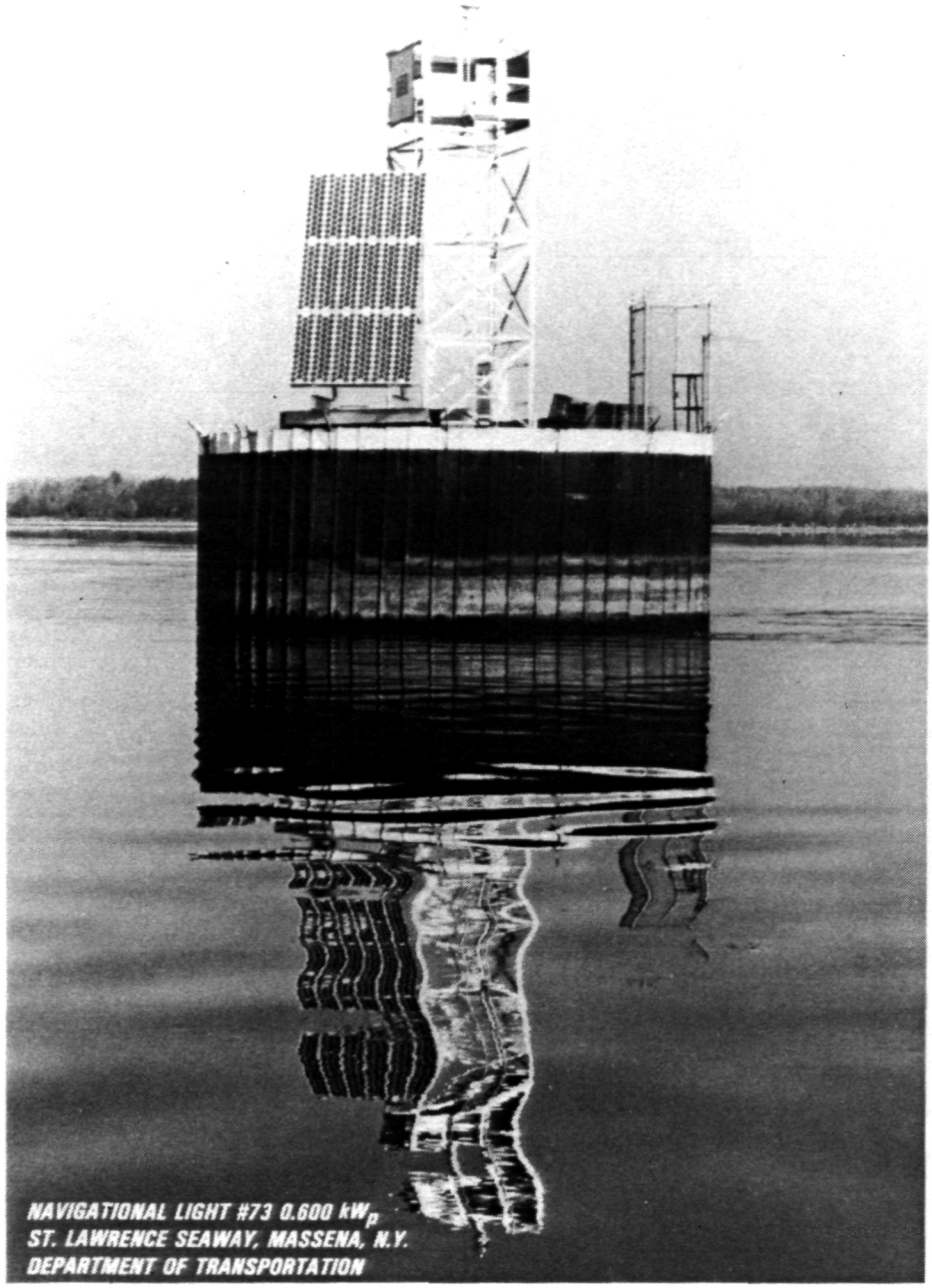
AGENCY DOE/Bonneville Power Administration CONTACT Gregory Smith

RATED POWER 0.420 kWp DC X AC _____

MODULES 12 (14 V, 35 Wp) BATTERIES 12 (2.5 V, 776 Ah)

PRESENT USE Relays radio signals

POTENTIAL USE Beacon, lighting



APPLICATION TITLE Superior Shoal Navigational Aid

APPLICATION LOCATION St. Lawrence Seaway, NY TYPE Beacon

AGENCY DOT/St. Lawrence Seaway CONTACT Richard Price

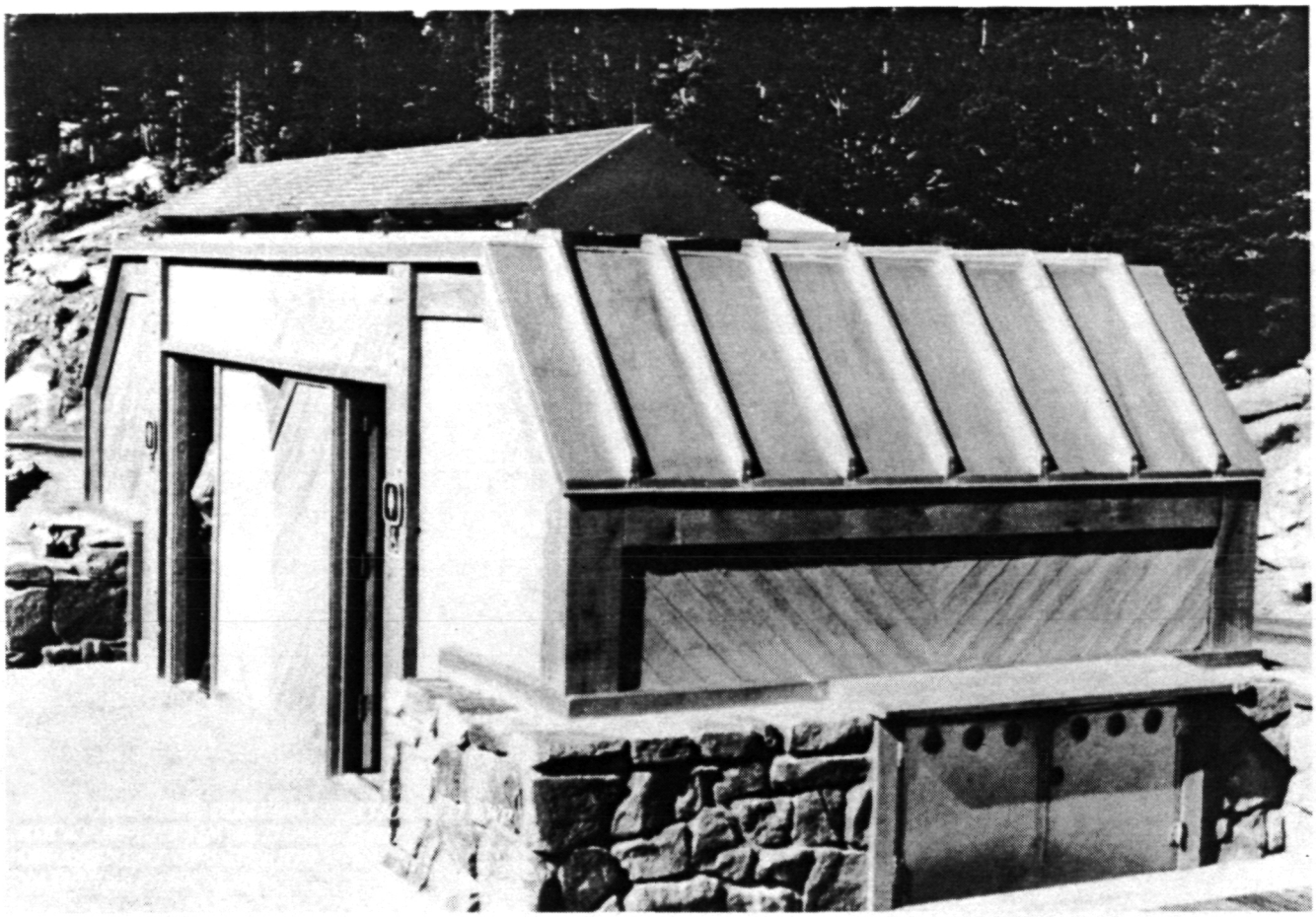
RATED POWER 0.600 kWp DC X AC _____

MODULES 18 (16 V, 37 Wp) BATTERIES 6 (2 V, 2100 Ah)

PRESENT USE Navigational light, visibility monitor

POTENTIAL USE Radio repeater, weather station

PUMPS



APPLICATION TITLE Comfort Station

APPLICATION LOCATION Rocky Mountain National Park, CO TYPE Pump

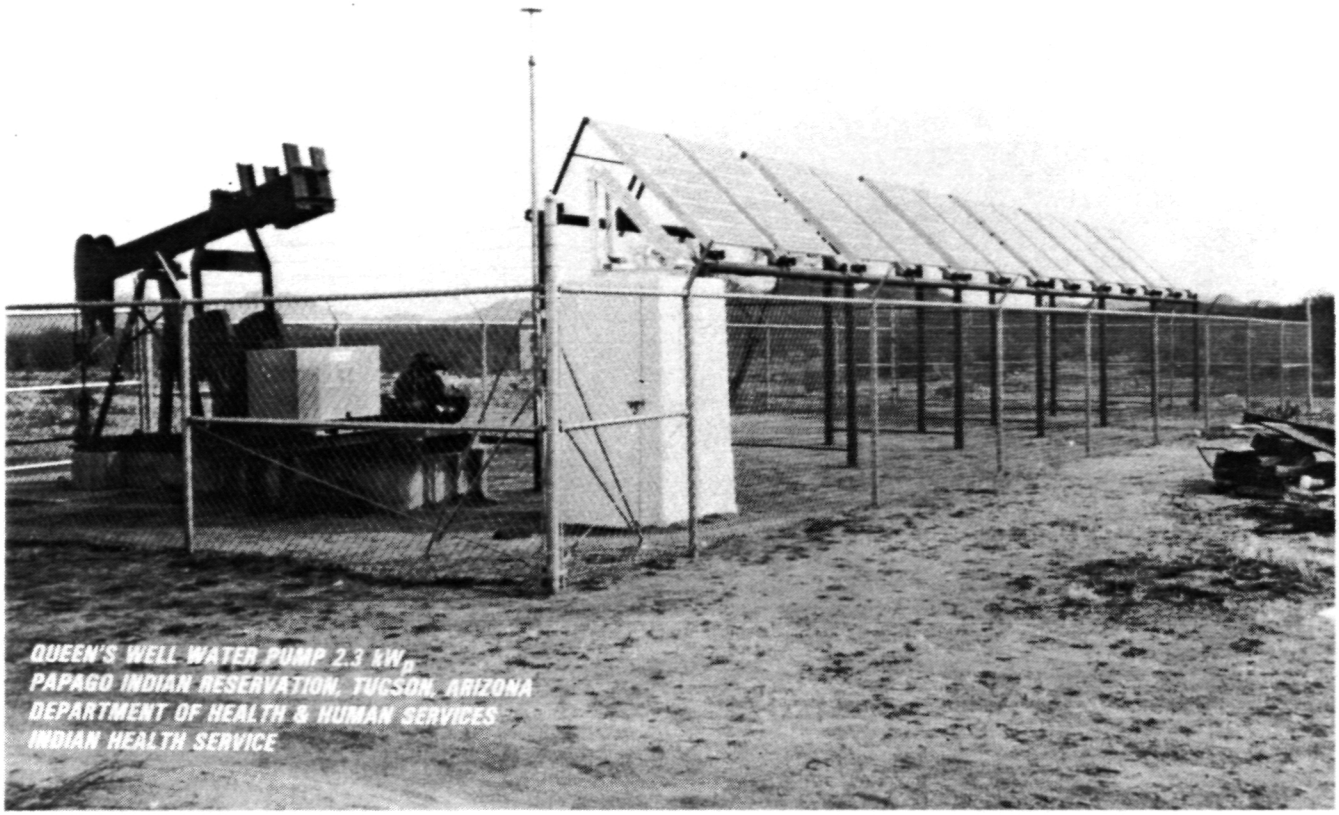
AGENCY DOI/National Park Service CONTACT Addison Hulse

RATED POWER 0.370 kWp DC X AC _____

MODULES 10 (28 V, 37 Wp) BATTERIES 3 (24 V, 300 Ah)

PRESENT USE Flush toilets in remote comfort station

POTENTIAL USE Lighting, radio communication



QUEEN'S WELL WATER PUMP 2.3 kW$_p$
PAPAGO INDIAN RESERVATION, TUCSON, ARIZONA
DEPARTMENT OF HEALTH & HUMAN SERVICES
INDIAN HEALTH SERVICE

APPLICATION TITLE Queen's Well

APPLICATION LOCATION Papago Reservation, Tucson, AZ TYPE Water Pump

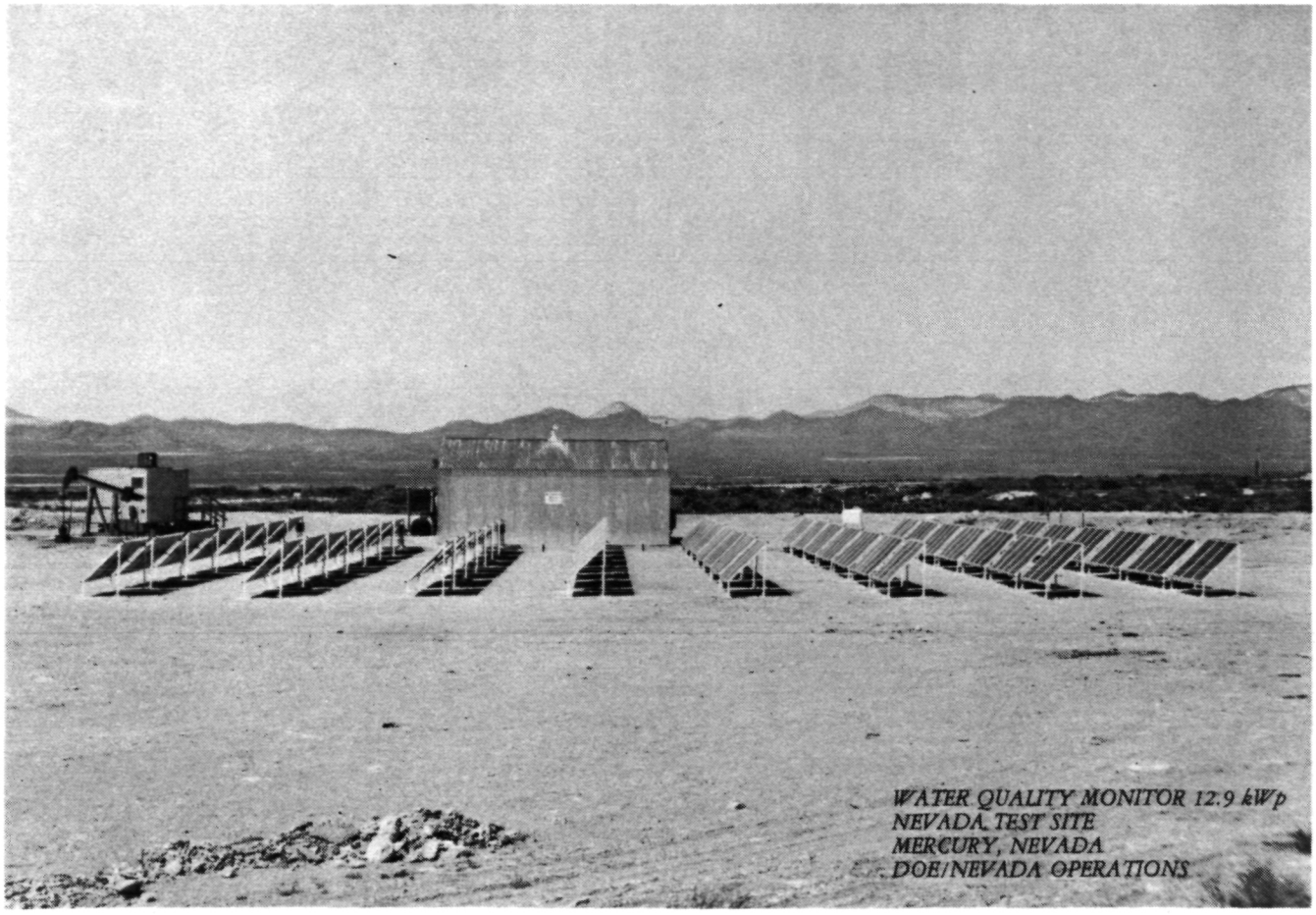
AGENCY DHH/Indian Health Service CONTACT Tom Park

RATED POWER 2.30 kWp DC X AC _____

MODULES 72 (15 V, 37 Wp) BATTERIES None

PRESENT USE Water Pumping

POTENTIAL USE Lighting, Radio Communication



APPLICATION TITLE Water Quality Monitor

APPLICATION LOCATION Nevada Test Site TYPE Water Pump

AGENCY DOE/Nevada Operations CONTACT Conway Grayson

RATED POWER 12.9 kWp DC X AC _____

MODULES 216 (5 V, 60 Wp) BATTERIES 60 (2.4 V, 2880 Ah)

PRESENT USE Pump water from 2000-foot well to monitor ground water radiation

POTENTIAL USE Radar

RADIO COMMUNICATION SYSTEMS

APPLICATION TITLE Hawley Mountain Lookout Tower

APPLICATION LOCATION Boise National Forest, ID TYPE Forest Lookout

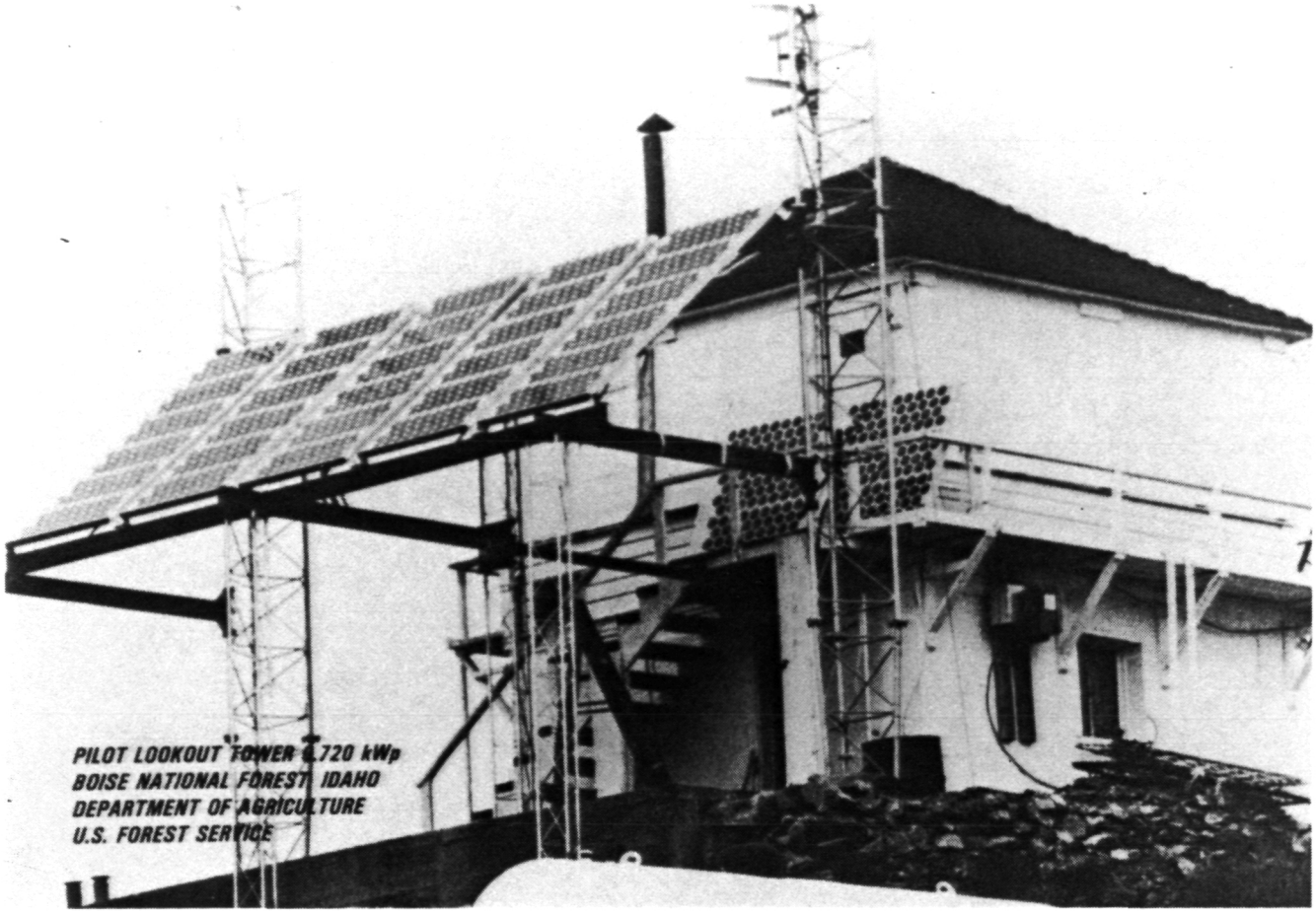
AGENCY DOA/U.S. Forest Service CONTACT Harold Mead

RATED POWER 0.228 kWp DC X AC _____

MODULES 18 (4 V, 16 Wp) BATTERIES 24 (2.2 V, 500 Ah)

PRESENT USE Radio communications

POTENTIAL USE Beacon



APPLICATION TITLE Pilot Peak Lookout Tower

APPLICATION LOCATION Boise National Forest, ID TYPE Forest Lookout

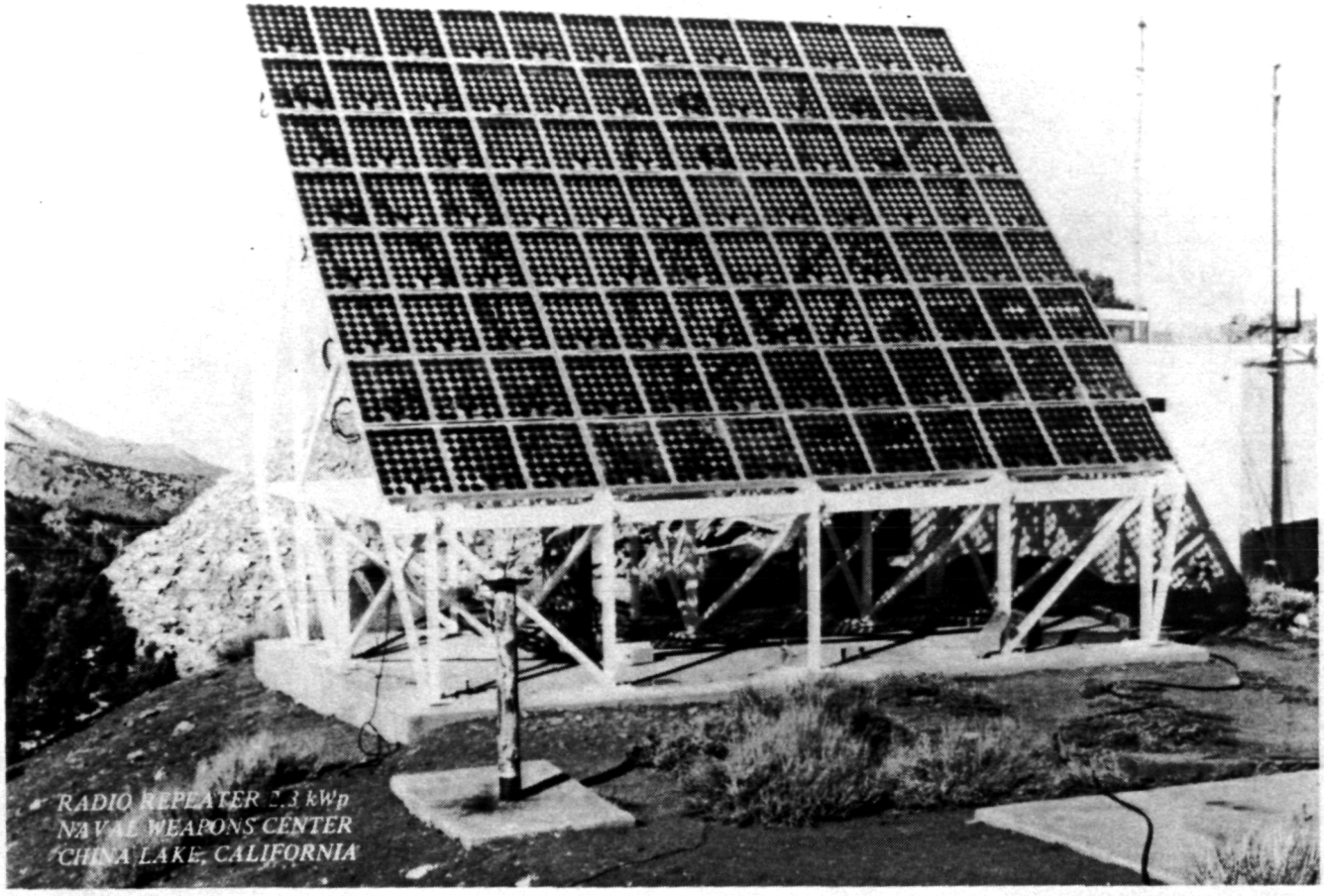
AGENCY DOA/U.S. Forest Service CONTACT Harold Mead

RATED POWER 0.720 kWp DC X AC _____

MODULES 30 (12 V, 24 Wp) BATTERIES 24 (6 V, 500 Ah)

PRESENT USE Radio communications, microwave repeater

POTENTIAL USE Beacon



APPLICATION TITLE AM Radio Repeater

APPLICATION LOCATION Naval Weapons Center, China Lake, CA TYPE Radio Communications

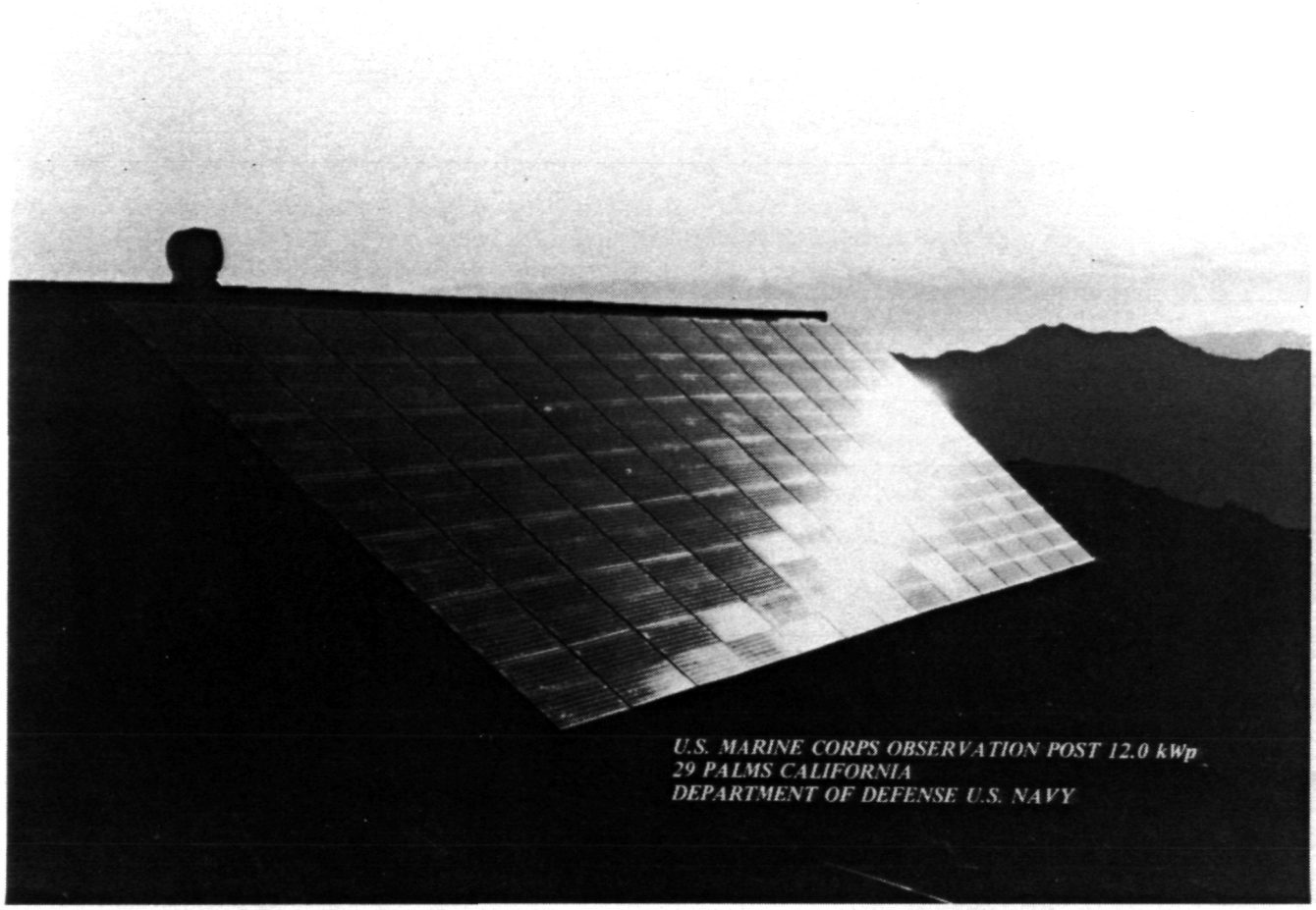
AGENCY DOD/U.S. Navy CONTACT Garyl Smith

RATED POWER 2.30 kWp DC X AC _____

MODULES 96 (15 V, 24 Wp) BATTERIES 32 (6 V, 6.3 Ah)

PRESENT USE Radio telecommunications

POTENTIAL USE Residence, water pump



APPLICATION TITLE Observation Post-Crampton

APPLICATION LOCATION U.S. Marine Corps Base, 29 Palms, CA TYPE Radio Communications

AGENCY DOD/U.S. Navy CONTACT Garyl Smith

RATED POWER 12.0 kWp DC _____ AC X

MODULES 364 (15 V, 33 Wp) BATTERIES 1026 (2 V, 500 Ah)

PRESENT USE Radio communication

POTENTIAL USE Water pumping, residence

RESIDENCES AND BUILDINGS

APPLICATION TITLE Navajo Home

APPLICATION LOCATION Navajo Reservation, NM & AZ TYPE Residence

AGENCY DHHS/Indian Health Service CONTACT John Leo

RATED POWER 0.444 kWp DC X AC _____

MODULES 12 (12 V, 37 Wp) BATTERIES 6 (2 V, 525 Ah)

PRESENT USE Lighting, small appliances, water pump

POTENTIAL USE Radio communication

BORDER CROSSING STATION 2.2 kW_p
TRAILCREEK, MONTANA
U.S. CUSTOMS SERVICE

APPLICATION TITLE Trail Creek Customs Inspection Station

APPLICATION LOCATION Port of Trail Creek, MT TYPE Residence

AGENCY DOTr/U.S. Customs CONTACT George Fors

RATED POWER 2.2 kWp DC _____ AC X

MODULES 48 (6 V, 65 Wp) BATTERIES 16 (6 V, 765 Ah)

PRESENT USE Lighting, refrigerator, water pump, fans

POTENTIAL USE Microwave repeater, radar

RESIDENTIAL POWER SYSTEM 0.150 kW_p
CUYAPAIPE, CALIFORNIA
INDIAN HEALTH SERVICE

APPLICATION TITLE Cuyapaipe Indian Home

APPLICATION LOCATION Cuyapaipe Reservation, CA TYPE Residential

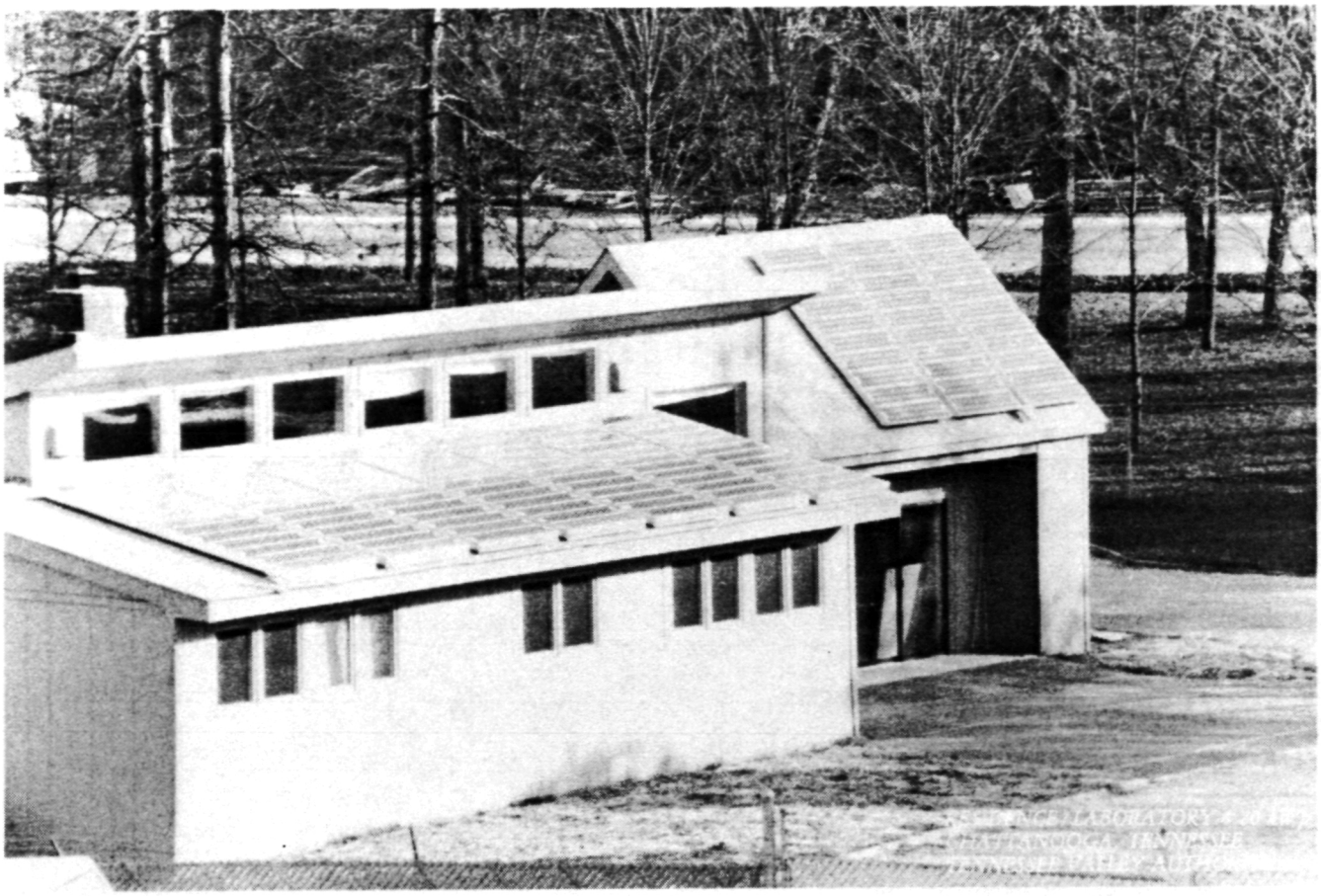
AGENCY DHHS/Indian Health Service CONTACT William Bigelow

RATED POWER 0.150 kWp DC X AC _____

MODULES 5 (5 V, 37 Wp) BATTERIES (12 V, 330 Ah)

PRESENT USE Lighting

POTENTIAL USE Beacon, intrusion detection



APPLICATION TITLE TVA Residence

APPLICATION LOCATION Chattanooga, TN TYPE Residential

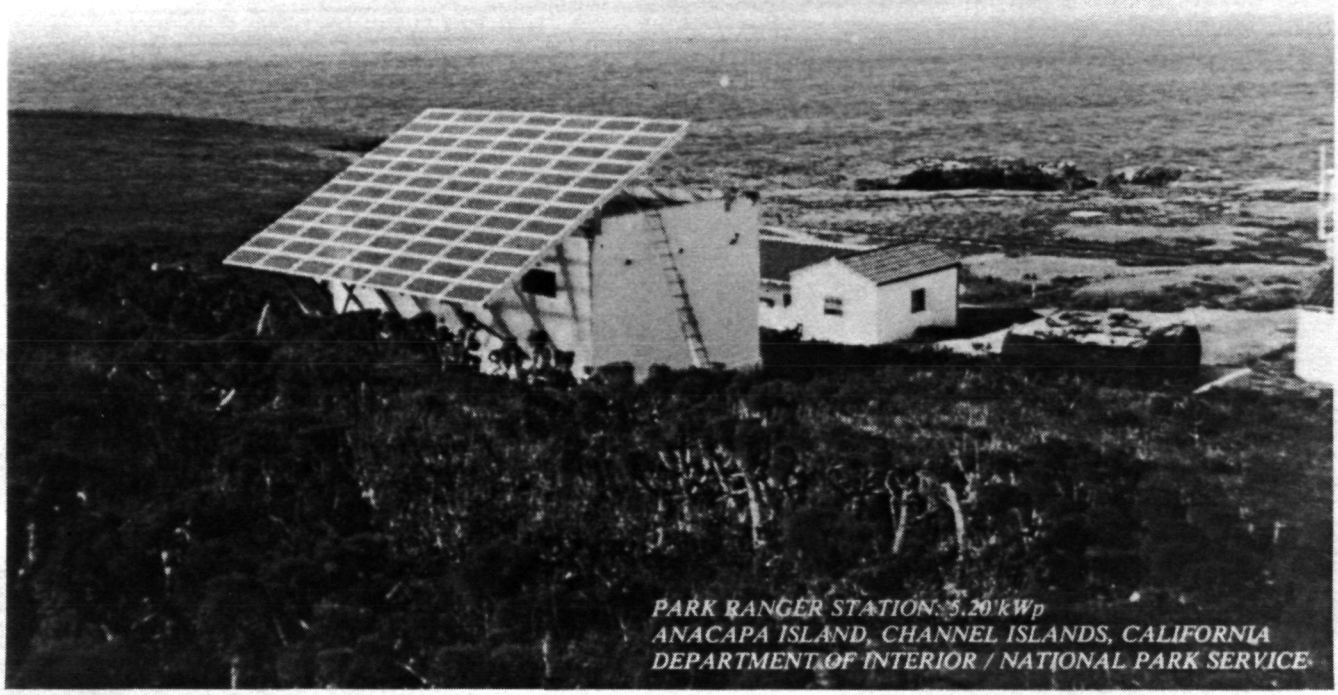
AGENCY Tennessee Valley Authority CONTACT Jim McKibben

RATED POWER 4.2 kWp DC _____ AC X

MODULES 112 (17.2 V, 40 Wp) BATTERIES None

PRESENT USE Grid-connected, lighting, home appliances

POTENTIAL USE Radio communication, radar



APPLICATION TITLE Park Ranger Station

APPLICATION LOCATION Anacapa Island, CA TYPE Residential

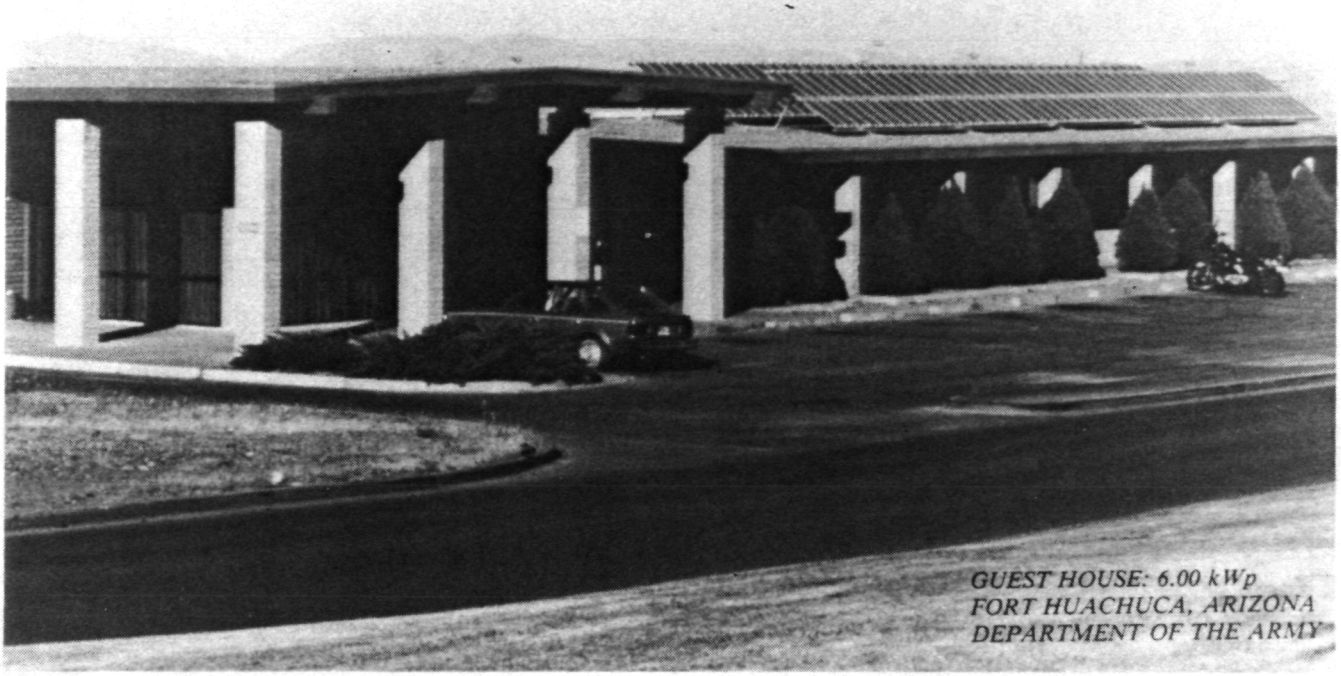
AGENCY DOI/National Park Service CONTACT Richard Davis

RATED POWER 5.20 kWp DC _____ AC X

MODULES 84 (4.7 V, 57 Wp/module) BATTERIES 84 (2 V, 639 Ah/battery)

PRESENT USE Lighting, household appliances, radio

POTENTIAL USE Water pump, radar, beacon



APPLICATION TITLE Holman Guest House

APPLICATION LOCATION Fort Huachuca, AZ TYPE Residential

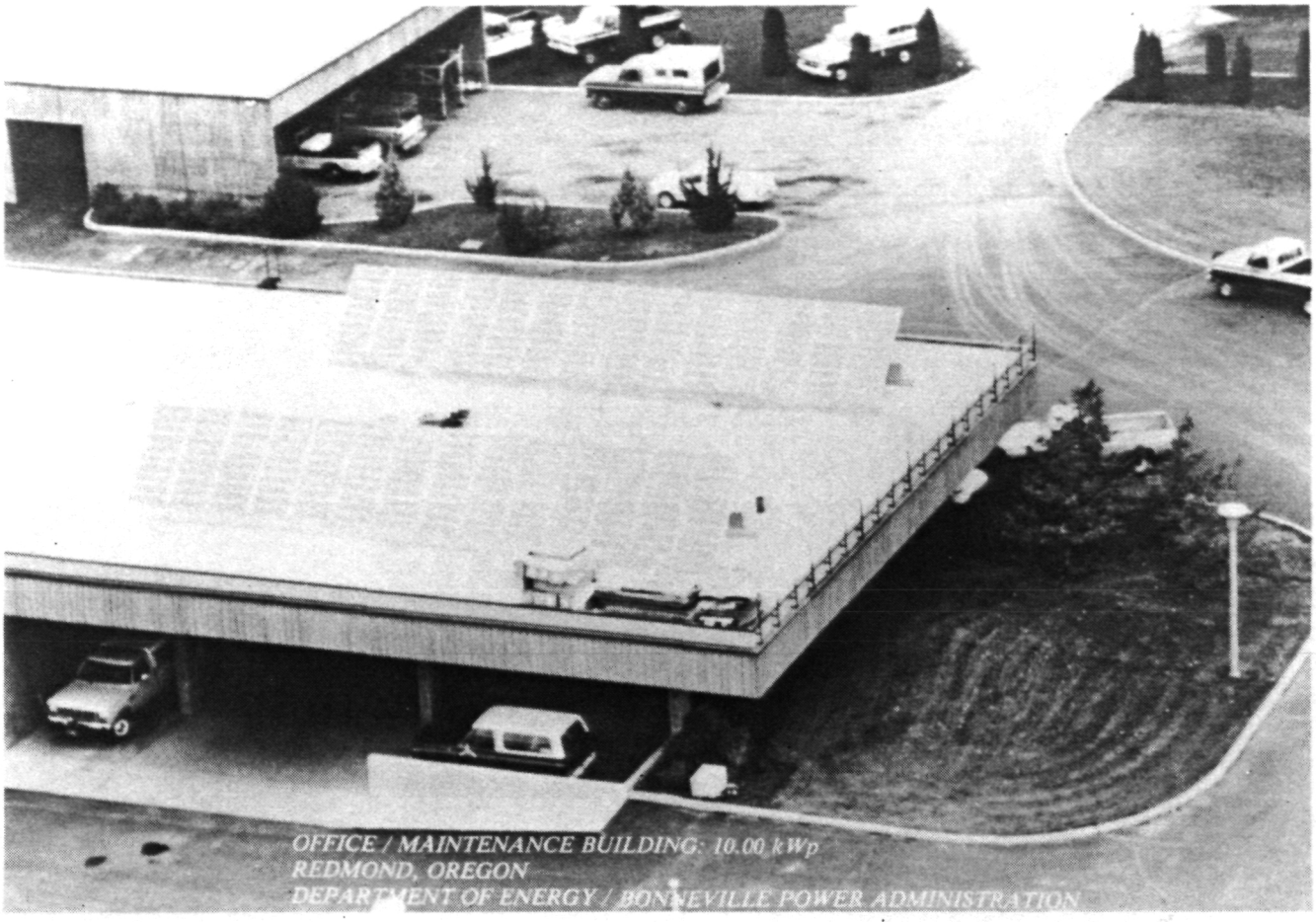
AGENCY DOD/U.S. Army CONTACT Sam Cerami

RATED POWER 6.00 kWp DC _____ AC X

MODULES 196 (12 V, 35 Wp) BATTERIES None

PRESENT USE Part of lighting

POTENTIAL USE Radar, water pumping



APPLICATION TITLE Power Substation Office/Maintenance Building

APPLICATION LOCATION Redmond, OR TYPE Office building

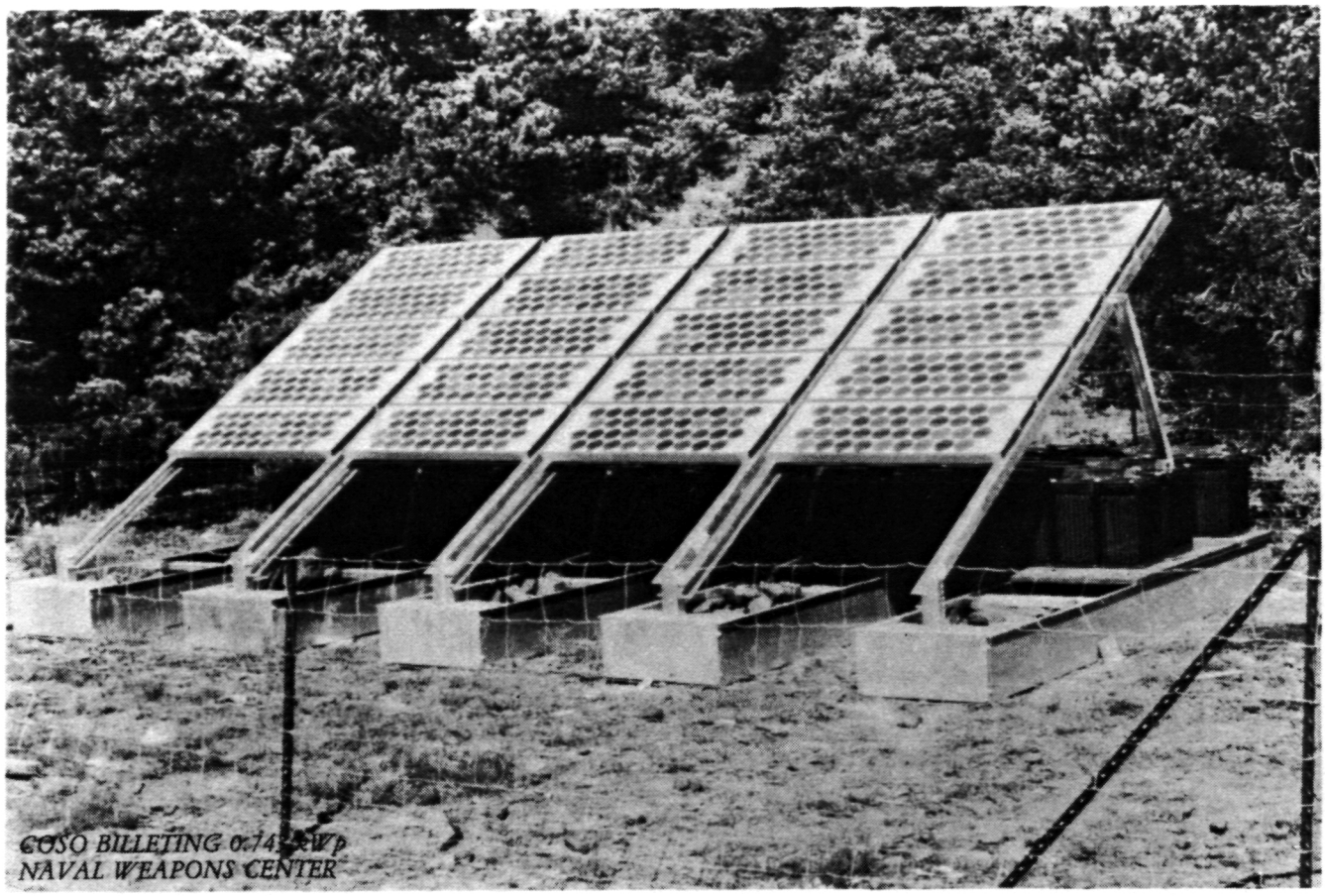
AGENCY DOE/Bonneville Power Administration CONTACT Minje Ghim

RATED POWER 10.00 kWp DC _____ AC X

MODULES 280 (36 V, 36 Wp) BATTERIES None

PRESENT USE Grid-connected. Part of lighting and air conditioning

POTENTIAL USE Residence, radar



APPLICATION TITLE Coso Billeting

APPLICATION LOCATION Naval Weapons Center, China Lake,CA TYPE Residential

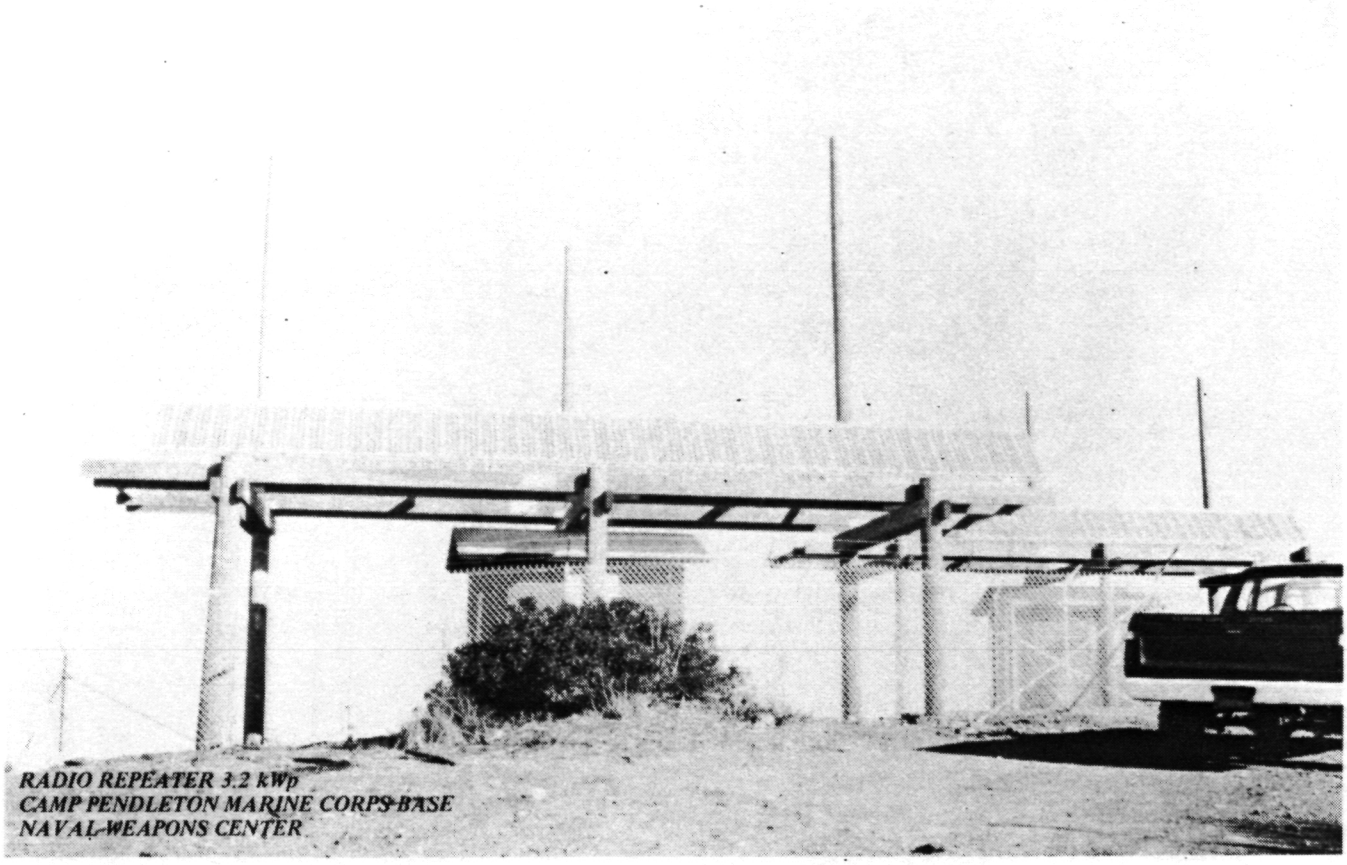
AGENCY DOD/U.S. Navy CONTACT Garyl Smith

RATED POWER 0.743 kWp DC _____ AC X

MODULES 20 (15 V, 37 Wp) BATTERIES 72 (2 V, 263 Ah)

PRESENT USE Lighting, refrigerator, radio communication

POTENTIAL USE Instrumentation



RADIO REPEATER 3.2 kWp
CAMP PENDLETON MARINE CORPS BASE
NAVAL WEAPONS CENTER

APPLICATION TITLE U.S. Marines Radio Repeater

APPLICATION LOCATION Camp Pendleton, CA TYPE Radio Communications

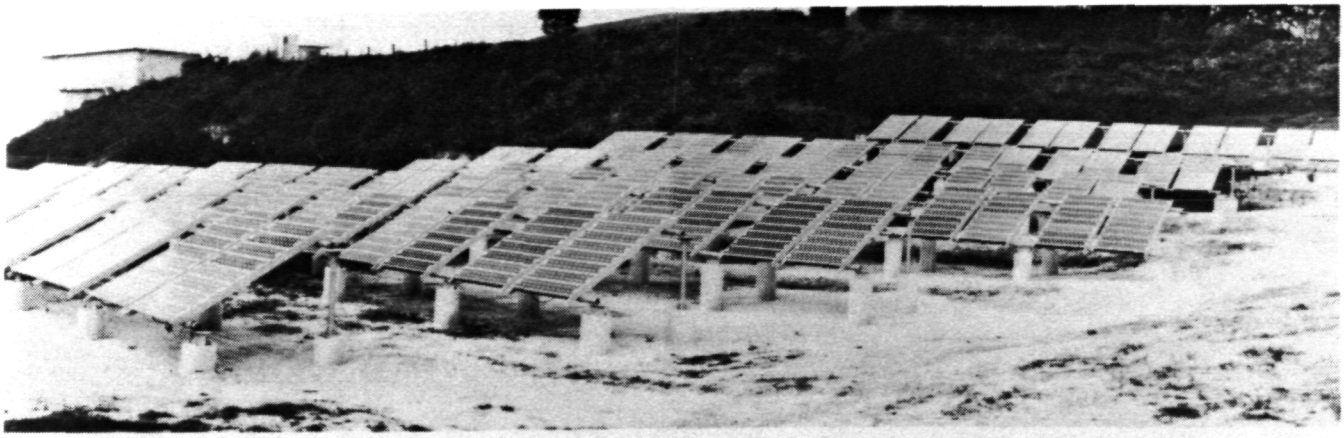
AGENCY DOD/U.S. Navy CONTACT Garyl Smith

RATED POWER 3.20 kWp DC X AC _____

MODULES 150 (16 V, 33 Wp) BATTERIES 60 (2 V, 1700 Ah)

PRESENT USE Relays radio signals

POTENTIAL USE Weather data gathering, beacon



TUDOR HILL RESEARCH LABORATORY 56 kWp
BERMUDA
DEPARTMENT OF THE NAVY

APPLICATION TITLE Tudor Hill Laboratory

APPLICATION LOCATION Bermuda, U.K. TYPE Commercial building

AGENCY DOD/U.S. Navy CONTACT Garyl Smith

RATED POWER 56.32 kWp DC _____ AC X

MODULES 1408 (12 V, 40 Wp) BATTERIES None

PRESENT USE Grid connected. Part of lighting and instrumentation

POTENTIAL USE Residential. Air control radar. Radio communication

SECTION VIII

FPUP INFORMATION TRANSFER DOCUMENTATION

A. INTRODUCTION

The U.S. Department of Energy provided assistance in many areas to the Federal agencies participating in the Federal Photovoltaic Utilization Program (FPUP). For example, they assisted in providing information transfer documents to guide Federal agency engineers in the implementation of photovoltaic applications at Federal facilities. These documents were either written, adapted, or used for FPUP purposes and are given as references in the Bibliography of this handbook.[1] They are briefly described below:

B. INFORMATION TRANSFER DOCUMENTS

1. Rejection Criteria for JPL LSSA Modules, JPL Internal Document 5101-21, Revision A, June 28, 1977

Defined in this document are the rejection criteria for silicon solar cell modules. The criteria, terminology and illustrations are derived from details of specific module designs. Especially useful are the illustrations specifically depicting the various types of defects that can be observed in silicon solar cell modules. These illustrations very clearly define acceptable defects and those which should cause a module to be rejected. The classes of defects covered are those pertaining to module identification, module mechanical features, solar cells, interconnects, soldering, encapsulation and foreign materials.

2. Solar Cell Module Design and Test Specification, JPL Internal Document 5260-5, August 1, 1979

This document establishes the requirements for the performance of flat-plate solar cell modules intended for use in photovoltaic applications at Federal facilities. In addition to module design and performance requirements, a series of characterization and qualification tests, as well as the performance tests for acceptance of modules, are also specified.

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[1] The documentation described in this chapter is available from the Federal Photovoltaic Utilization Program Office, at the Jet Propulsion Laboratory, 4800 Oak Grove Drive, Pasadena, California, 91109.

3. Federal Photovoltaic Utilization Program System Criteria Documents, Vols. I-V, JPL Internal Document 5260-6, December 1, 1979

Included in this five-volume publication are discussions of:

(1) Quality assurance criteria for manufacturers and installers of photovoltaic power systems.

(2) Guidelines for evaluating the management and operations planning of photovoltaic applications.

(3) Environmental issues and evaluation criteria for photovoltaic applications.

(4) Guidelines for the organization, preparation, and conduct of program reviews, including design reviews.

(5) Methodology for determing potential safety hazards for photovoltaic applications.

The purpose of the criteria documents is to provide information to assist Federal agencies in implementing photovoltaic applications in a timely, cost-effective and safe manner. In addition, these documents are intended to provide guidance in achieving systems with consistently acceptable performance.

4. Federal Photovoltaic Utilization Program Implementation Plan Guidelines, JPL Internal Document 5260-8, Revision A, February 1, 1981

An Implementation Plan was requested by DOE from each Federal agency participating in FPUP. This plan was to include funding, system procurement, system design, installation, monitoring, and assessment associated with each photovoltaic application or group of similar applications. To assist the agencies in preparing their Implementation Plans, this document was published in a format to reflect the principal sections of such a plan. Also included in this document are standard forms to be filled in by the agencies to facilitate the reporting requirements of FPUP, a copy of the FPUP Rules and a list of photovoltaic system suppliers.

SECTION IX

REFERENCES

1. Hall, M. R., Smith, G. D., and Holmes, D. L., Flat Plate Photovoltaic Power Systems: Description, Design, and Cost, NWC TP 6381, Naval Weapon Center, China Lake, California, July 1982.

2. Economic Analysis Handbood, Naval Facilities Engineering Command, NAVFAC 442, Alexandria, Virginia, June 1975.

3. Smith, J. H., Handbook of Solar Energy Data for South-Facing Surfaces in the United States, Volume 1: An Isolation, Array Shadowing, and Reflector Augmentation Model, DOE/JPL1012-25, Vol. 1, JPL Publication 79-103, Jet Propulsion Laboratory, Pasadena, California, January 15, 1980.

4. Solar Cell Array Design Handbook, NASA-JPL SP 43-38, Vol 1, Jet Propulsion Laboratory, Pasadena, California, October 1976.

5. Rejection Criteria for JPL LSSA Modules, JPL Document 5101-21, Revision A, Jet Propulsion Laboratory, Pasadena, California, June 28, 1977.

6. Solar Cell Module Design and Test Specification, JPL Document 5260-5, Jet Propulsion Laboratory, Pasadena, California, August 1, 1979.

7. Federal Photovoltaic Utilization Program System Criteria Documents, Vols. I-V, JPL Document 5260-6, Revision A, Jet Propulsion Laboratory, Pasadena, California, December 1, 1979.

8. Federal Photovoltaic Utilization Program Implementation Plan Guidelines, JPL Document 5260-8, Revision A, Jet Propulsion Laboratory, Pasadena, California, February 1, 1981.

9. Stand-Alone Flat-Plate Photvoltaic Power Systems: System Sizing and Costing Methodology, JPL Document 5260-32, Jet Propulsion Laboratory, Pasadena, California.

APPENDIX A

SAMPLE SECTIONS OF REQUEST-FOR-PROPOSAL FOR CIVILIAN PHOTOVOLTAIC APPLICATIONS

SECTION B

SUPPLIES/SERVICES AND PRICES

The Contractor shall provide all services, labor and materials for design, fabrication, assembly and installation of a solar electric photovoltaic power system in accordance with Section "C" titled Description/Specifications. The system shall be located on Anacapa Island, Channel Islands National Park, California.

ITEMS AND PRICES

ITEM NO.	DESCRIPTION	ESTIMATED QUANTITY	UNIT	UNIT PRICE	TOTAL AMOUNT
001	AVERAGE 1 KVA SOLAR ELECTRIC PHOTOVOLTAIC SYSTEM	1	SYS	_____	_____
002	INSTALLATION, OPERATION AND MAINTENANCE MANUALS AND SHOP DRAWINGS	2	SET	_____	_____
003	ACCEPTANCE TEST PLAN	2	EA	_____	_____
			TOTAL		$_____

SECTION C

DESCRIPTION/SPECIFICATIONS

1.0 INTRODUCTION

1.1 The National Park Service has a need to procure a Photovoltaic Power System. The procurement is for a system to be located on Anacapa Island, Channel Islands National Park, California.

2.0 SCOPE

2.1 The scope of this effort covers the requirements for the design, fabrication, assembly and installation of a complete Photovoltaic Power System. This system shall include (but not necessarily be limited to): solar cell modules; power conditioning equipment and battery storage components installed and interconnected into suitable frames; load management switching equipment for back-up diesel generator; interconnecting wiring and control systems and commercial manuals described in paragraph 5.2 .

2.2 Except as modified herein, materials, equipment, and installation shall be provided in accordance with standards and nationally recognized model codes. State and Local codes which deviate from Nationally recognized codes or standards, in order to satisfy local conditions, may be accepted if such deviations are identified and substantiated with satisfactory engineering data.

3.0 APPLICABLE DOCUMENTS

3.1 The following documents are included as part of this specification, See Part III, Section J, Attachments A & B: JPL-5260-5, "Solar Cell Module Design and Test Specification", August 1979 JPL-5101-21, Revision A, "Low-Cost Solar Array Project Rejection Criteria for JPL LSSA Modules", August 1977.

3.2 The following documents are identified in the Defense Index of Specifications and Standards (DoDISS) Part II, 1 July 1979, and Bi-Monthly Supplement, 1 September 1971, form a part of this requirement to the extent specified herein and are available as described in Standards and Descriptions (1977 JUN) DAR 7-2003.8.

MIL-A-8625C (1), Anodic Coatings, for Aluminum and Aluminum Alloys, 13 March 1969.

MIL-STD-461A, Electromagnetic Interference Characteristics Requirements for Equipment, 1 August 1968, and Notice 6, 3 July 1973.

MIL-STD-810C, Environmental Test Methods, 10 March 1975.

4.0 TECHNICAL TASKS

4.1 The Contractor shall provide all materials and services to design, fabricate, assemble, install and test the required photovoltaic power system.

4.2 General Requirements

4.2.1 Solar Cell Modules. The solar cell modules used in the required photovoltaic power system shall meet all conditions as specified in JPL Solar Cell Module Design and Test Specification 5260-5, except, Paragraph B-4, page 2.3 shall read:

> Cell String Circuit Reliability/Redundancy - Circuit redundancy features shall be incorporated to ennance the reliability of solar photovoltaic modules. Design features shall include, but are not limited to the following:
>
> (a) Redundant interconnections between solar cells, including redundant cell attachment points
>
> (b) Series/parallel interconnection of cells within the module
>
> (c) Integral by-pass diodes within each module
>
> Series/parallel circuit arrangements shall be designed so that "hot-spot" cell heating does not lead to furtner module degradation under worst-case-single-cell-failure conditions defined as follows:
>
> (a) The module output is short circuited
>
> (b) A single representative solar cell is open circuited to represent a single cell failure
>
> (c) The incident irradiance is 100 mW/cm^2, AM1.5
>
> (d) The thermal boundary conditions are adjusted so that the equilibrium solar cell temperature outside of the hot-spot region is equal to NOCT + 20°C

4.2.1.1 Additional Module Requirements. Each module shall contain output terminals to permit interconnection of modules into either parallel or series arrangements. The output terminals shall be located witnin a water-proof interconnection box. The module and interconnection box shall be designed to operate in, and survive, a marine environment. Reference 4.3.1.1.

4.2.2 Solar Cell Frames and Mounting Stands

4.2.2.1 Mechanical Construction. The structure shall be self-supporting, consisting of a panel frame assembly with legs and provision for tie-down. The module to frame connections shall be made witn fasteners described in section 4.2.5.4.

4.2.2.2 Interchangeability. For each application, the solar cell modules shall be interchangeable; the power conditioning equipment shall be interchangeable; and the panel frame components shall be interchangeable.

4.2.2.3 Materials. The photovoltaic power system support structure shall be made of a metal with corrosion-resisting treatment suitable for a marine environment acceptable to the Contracting Officer's Technical Representative.

4.2.2.4 Grounding. The panel structure shall incorporate a ground stud for connecting ground cables/strips.

4.2.2.5 Lightning Protection. The photovoltaic power system shall have means for protection from lightning flashes.

4.2.3 Power Conditioning.

4.2.3.1 Power conditioning equipment will be required for the system as specified.

4.2.3.2 Blocking Diodes. Blocking diodes shall be used to prevent battery discharge through the array and the voltage regulator.

4.2.4 Battery Storage System.

4.2.4.1 Battery Enclosure. The photovoltaic power system shall have an enclosure for the batteries that is ventilated and protects the batteries from entrance of water and minimizes the entrance of dust and dirt, etc.

4.2.5 System Design Requirements

4.2.5.1 Lifetime Consideration. The system shall be designed for a minimum lifetime of 10 years.

4.2.5.2 Warranty. It is understood and agreed that the photovoltaic system will be fit for and operate in accordance within the system performance requirements specified in the contract for a period of not less than two years after acceptance by the government. All necessary adjustments occasioned by failures not caused by misuse or accident through fault and negligence by the government shall be made at the contractor's expense; including, without limitation: inspection by the contractor at the installation site; labor; parts; and, transportation costs, if any.

4.2.5.3 Fasteners (except electrical). Fasteners shall be from passivated stainless steel with American National coarse threads required where threads are provided in aluminum, magnesium or plastic parts. Bolts, screws and other fasteners used on rotating parts shall be provided with positive locking devices or means which do not depend on spring action or friction for their locking action, such as lock plates, lock wire, snap rings, castellated nuts and cotter pins. Means for locking fasteners on all non-rotating parts shall also be provided. Swedging, peening, or stalking of threads will not be acceptable as a locking device. Sheet metal screws shall not be used except in fastening of nameplates and instruction plates. All fasteners (bolts, screws, studs, etc.) shall be made of corrosion-resisting material or shall be treated to be corrosion-resisting.

4.2.5.4 Fasteners (electrical). Lock devices shall be provided each fastener used in making an electrical connection. Each fastener, locking device and other hardware (washers, etc.) shall be made of corrosion-resisting material or shall be treated to be corrosion-resisting. Fasteners (bolts, screws, studs, etc.) shall not be depended on to carry current; they shall serve merely to hold current-carrying parts (lugs, terminals, etc.) in firm contact with each other. Where flow of current cannot be avoided, the stud and all its associated hardware (nuts, locking devices, washers, etc.) shall be made of corrosion-resisting material. Positive means (such as pins or square shanks) shall be provided for preventing turning of studs in their mountings when nuts are tightened or loosened; lock washers which depend on friction or spring action will not be acceptable for this purpose.

4.2.5.5 Subsystem Isolation. Plug and socket-type connectors shall be provided to isolate the battery system; the power conditioner/array; and the load. The connectors shall have a positive locking device. The connectors shall be located such that they are current-carrying elements. A connector (male and female) shall be supplied to connect photovoltaic power system to the load. The Government will supply the wire from the load to the connector.

4.2.5.6 Wiring. All wire shall be neatly laced into harnesses through the use of fungus-resistant cord or self-locking nylon straps. Harness and individual wire shall be so run and clamped (with insulated clamps) as to protect wire insulation against contact with sharp corners and edges, pinching, sharp bending and twisting and abrasion because of vibration or contact with moving parts. The clamps shall also serve to prevent transmittal of mechanical stress to internal connections of electrical components. Where a cable or wire is run between parts which move relative to each other, sufficient slack shall be left in the harness. Wires shall not be spliced at any point throughout the length of their runs. All harnesses used to interconnect assemblies shall terminate in qualified connectors at each end or branch. Connectors outside of enclosures shall be potted where wires exist or seals shall be used to prevent entrance of water, dust, dirt, etc. Open, exposed connections will not be permitted. Not more than two terminal lugs shall be attached to any one stud on stud-type terminal boards. Solder terminals on electrical components shall not have more than two wires attached, unless specific written approval is obtained from the Contracting Officer's Technical Representative.

4.2.5.7 Electrical Materials (wire, insulation, connectors, fasteners, grounds, etc.). All electrical materials used shall conform to the National Electrical Code.

4.2.5.8 Dissimilar Metal Combinations. When it is necessary that any combination of dissimilar metals be assembled, the requirements as specified in MIL-STD-454E, requirement 16, shall be employed for the alleviation of corrosion.

4.2.5.9 Fixed Tilt Angle. The array tilt angle shall be determined by the Contractor based on load, duty cycle and location to balance array size and battery capacity for minimum system cost. The tilt angle shall be fixed.

4.2.5.10 Environment. The photovoltaic power system shall be designed to operate in and survive a marine environment.

4.2.5.11 Batteries. The storage batteries shall be lead acid secondary, float service type. The self-discharge rate shall not exceed 2% per month at 77°F. The batteries shall be a low water loss type and should have a high discharge capability and be provided with an audible and visual low voltage cutout. The batteries should be suitable for a marine environment.

4.2.5.12 Inverter - Solid State. The photovoltaic power system shall have a DC to AC inverter located between the batteries and the load. The inverter shall be solid state with the input voltage compatible with the battery system voltage. The inverter output shall be: 120 VAC, single phase, 60 cycle ±1%, circuit breaker protected, be capable of operating in a marine environment, and have an overall efficiency of at least 90%.

(a) Each harmonic frequency generated by the PV system shall be limited by system by filtering to no more than 1% of the PV systems rated current and voltage at the fundamental 60 Hertz frequency.

(b) Telephone interference shall be minimized by limiting the telephone influence factor (TIF) to a value of 20. The IT products (current X TIF) measured should not exceed 1500. The residual IT products shall exceed 350.

4.2.5.13 Instrumentation. The system shall have an input and output voltmeter and ammeter as well as a watt meter for the array and batteries.

4.3 Specific Requirements

4.3.1 Photovoltaic Power System for residential use on Anacapa Island, Channel Islands National Park, California.

4.3.1.1 Environment. The photovoltaic power system shall be designed to operate in and survive the following environment:

Environment	Operate	Survive
Ambient Temperature	+35°F to +80°F	+30°F to +100°F
Humidity	50 to 100%	50 to 100%
Cyclic load		+50 lb/ft^2 to -50 lb/ft^2 100 times, cycle rate shall not exceed 20 cycles/min.

Wind		Up to 80 knots
Hail		As specified in JPL-5260-5
Marine	Salt water spray	Salt water spray. Water entry into connectors and batteries shall be considered unacceptable.

4.3.1.2 Power Requirements and Duty Cycle. The system shall meet the following power requirements:

(a) System voltage 120 VAC 60 Hertz

(b) Average load 1000 Watts, 7 days/week.

4.3.1.3 Battery Storage Requirements. The battery storage shall be designed to supply the specified power requirements for not less than 5 consecutive sunless days. The battery storage system shall be designed to meet the environmental requirements of section 4.3.1.2.

4.3.1.4 Power Conditioning Requirements. The power conditioning shall consist of a solid state device. The device shall control the charging voltage on the batteries at 2.3 to 2.4 volts/cell so as to minimize battery gassing and water loss. This device shall also have a low-voltage cutoff at 1.9 volts/cell to protect the batteries from damage.

The photovoltatic power system shall have a DC to AC inverter located between the batteries and load that meets or exceeds the following specifications:

(a)	Input voltage	22 VDC to 30 VDC
(b)	Output power	(Approx.) 10 KVA
(c)	Voltage	115V rms sine wave
(d)	Voltage regulation	± 5% under all conditions of load and operating temperature
(e)	Single phase	
(f)	Frequency	60 Hz ± 1% under all conditions of load and operating temperature
(g)	Harmonic distortion	Less than 5%

(h)	Power factor	.75 lagging to .75 leading
(i)	Protection	Overload and short circuit
(j)	Operating temperature	-10°C to +55°C
(k)	Efficiency	Greater than 90% at rated power
(l)	Humidity	Operate at 100% RH @ 30°C
(m)	RFI	Able to meet MIL-I-6181D

4.3.1.5 Frame. The frame shall be designed and constructed such that all components of the system are secured surely and safely to the frame. The frame shall have a means of anchorment such that extensive site preparation and/or concrete are not required. The frame shall be bolted to a base that is bolted to the walls of the fuel building. The frame shall hold the panels at the required tilt angle.

The frame shall have legs that are adjustable. The leg adjustment shall be in increments of 1-inch and shall provide for a minimum adjustment of 2-feet in length per leg. A positive locking device shall be used for leg adjustment (bolts through holes, etc.). Friction-locking devices for leg adjustment will not be acceptable.

4.3.1.6 Load Management Switching Equipment.

(a) Charge Controller - The charge controller shall protect the batteries from overcharging and shall shut off the load when the batteries are below 30% of their charge capacity.

(b) Power Returner - The loads will automatically come back on line when the battery has regained a sufficient charge.

(c) Modular Component - The control unit shall be modular so the replacement of components can be made easily.

(d) Indicators - A volt meter to monitor the state of battery shall be included. Also included shall be an array output voltmeter and ammeter.

5.0 REPORTS, DATA AND OTHER DELIVERABLES

5.1 The Contractor shall deliver documents as required by the Contractor Data Requirements List to:

National Park Service
Western Regional Office
450 Golden Gate Avenue
P.O. Box 36063
San Francisco, CA 94102
Attn: Maintenance and Engineering Division

5.2 Submit a manual prepared in the Contractor's standard format to the minimum content listed. The manual is to be used for operation, maintenance and logistic support of the system. The manual shall be delivered concurrent with the power system. The minimum requirements for the manual shall include:

5.2.1 Description. This chapter shall include but not limited to the following:

- a full page composite illustration of the equipment
- an illustration(s) calling out the major assemblies with their nomenclature
- a basic description of the type of equipment and its purpose
- a function block diagram
- tables listing equipment supplied and equipment required, but not supplied
- tables of technical, environmental and physical characteristics

5.2.2 Installation. This chapter shall include: See 5.2.1.

- information on unpacking, proper location of units,
- interconnections and initial pre-operational adjustments
- details of cables and ground requirements and cable fabrication (as applicable)
- illustrations of interconnections and front and rear panel jacks and their respective functions

5.2.3 Operation

This chapter shall include: See 5.2.1.

- step-by-step procedures for starting, operating and stopping the equipment
- meter readings and/or results expected from properly adjusted and operated equipment
- tables and illustrations calling out all operational controls and indicators and their functions (All reference to controls and indicators throughout the manual shall follow designations
- maintenance procedures which may normally be performed by the operator

5.2.4 Principles (or Theory) of Operation. This chapter shall include: See 5.2.1.

- a complete functional description of the equipment, based on a block diagram
- for complex mechanical features, a complete explanation, using block diagrams, exploded views, or cutaway drawings.
- major assemblies broken into individual circuits, accompanied by complete circuit analysis keyed to simplified schematic (where circuit complexity requires)
- brief description of conventional circuits
- detailed descriptions of complex and novel circuits
- waveforms of voltage at significant points in pulse or digital circuits

5.2.5 Maintenance (Preventive/Corrective). This chapter shall include: See 5.2.1.

- a schedule of detailed maintenance adjustments and procedures
- a list of recommended test equipment
- lubrication data
- information that permits a technician to locate trouble and to make repairs or adjustments to the equipment
- for complex equipment or where the procedure is not obvious, an outline of disassembly and reassembly procedures

- details of special test procedures
- complete adjustment and maintenance information for relays and other electro-mechanical devices
- oscilloscope waveforms illustrated with peak voltage, duration, repetition rate, and control positions

5.2.6 Parts List. The parts list shall consist of a tabulation of descriptive data on all electrical components and repairable/replaceable commercial or vendor mechanical components in the equipment. All parts shall be sufficiently described to implement reorder/replacement. The parts list shall contain at least the following information:

(a) Reference designation
(b) Name and description of part
(c) True Manufacturer's code (and list of Manufacturers' codes and addresses)
(d) NSN/JAN/MIL or true manufacturer's part number
(e) Quantity

5.2.7 Drawings. In addition to drawings previously specified, the following shall be included:

(a) Schematic diagrams of individual major practicable, printed wiring boards and where practicable, of the complete equipment
(b) Logic diagrams
(c) Interconnection diagrams
(d) Cabling diagrams
(e) Wiring diagrams
(f) Illustrations that identify and call out all circuit components

6.0 SPECIAL CONSIDERATIONS

6.1 Design Reviews. Design reviews will be held during the following stages of design, testing, and installation:

6.1.1 25% Design Review. When the major system components and configuration has been selected and what the general layout will be.

6.1.2 100% Design Review. When the entire system design has been completed.

6.1.3 Module Production Acceptance Requirements. Government assigned personnel shall be present during the time the photovoltaic panels are undergoing performance testing at the point of manufacture. Module acceptance shall be based on meeting the following requirements:

6.1.3.1 Electrical Performance. Each module shall be measured to obtain its current-voltage characteristics (I-V curve). The module output power at SOC and V_{no} shall be determined in accordance with Section IV, paragrapn A, JPL Specification 5260-5. No module shall be accepted for delivery which produces less than 90 percent of the average module output power (Pavg) under Standard Operating Conditions.

6.1.3.2 Electrical Isolation. Each module shall withstand the dc Hi-Pot test, per Section III, paragraph B.2, JPL Specification 5260-5 to assure adequate electrical isolation for safety of operating personnel at system operating voltages.

6.1.3.3 Mechanical and Visual Inspection. Modules shall be mechanically and visually inspected on the basis of criteria contained in JPL Document 5101-21, Revision A, defining acceptable/rejectable levels of workmansnip and quality.

6.1.4 Final Operation Review. Once the system has been completed and is operational there will be an onsite meeting between the Contractor and Goverment personnel to evaluate system performance.

6.1.5 Design Review Notification. The Contractor shall notify the Contracting Officer at least two weeks prior to each stage of the design review. Approval of the designs by the Contracting Officer's Technical Representative is required prior to fabrication of system components, assembly and installation of photovoltaic power systems.

SECTION D

PACKAGING AND MARKING

1. Preservation, packaging and packing and marking for all items delivered hereunder shall be in accordance with commercial practice and adequate to insure acceptance by common carrier and safe arrival at destination. All material should be palletized to the maximum extent possible for unloading in a marine environment. Materials should be encased in plastic to resist salt spray during transhipment. When applicable, special handling instructions shall accompany each package requiring special handling.

   The Contractor shall be the responsible party during shipment and transhipment. The Government shall not be liable for any damages to any equipment that may occur during shipment or transhipment.

2. The Contractor shall package and ship all deliverable items in shipping cartons and shall place, on or adjacent to the exterior shipping label, the contract number and the park location for identification purposes. A content list shall be included in each pack.

3. The Contractor shall provide unpacking instructions as follows:

   a. Location on Container. When practical, one set of the unpacking instructions will be placed in a heavy waterproof envelope prominently marked "UNPACKING INFORMATION" and firmly affixed to the outside of the shipping container in a protected location, preferably between the cleats on the end of the container adjacent to the identification marking. If the instructions cover a set of equipment packed in multiple containers, the instructions will be affixed to the number one container of the set. When the unpacking instructions are too voluminous to be affixed to the exterior of the container, they will be placed inside and directions for locating them will be provided in the envelope marked "UNPACKING INFORMATION".

   b. Marking Containers. When unpacking instructions are provided, shipping containers will be stenciled "CAUTION--THIS EQUIPMENT MAY BE SERIOUSLY DAMAGED UNLESS UNPACKING INSTRUCTIONS ARE CAREFULLY FOLLOWED. UNPACKING INSTRUCTIONS ARE LOCATED (state where located)." When practical, this marking will be applied adjacent to the identification marking on the side of the container.

SECTION E

INSPECTION AND ACCEPTANCE

1. INSPECTION OF WORK IN PROGRESS

   a. The NPS reserves the right to periodically inspect all phases of the work while in progress or after completion of the whole or any part thereof to insure that the work is performed in compliance with the terms of the contract. If the Government determines that the work is not being performed in accordance with the specifications, the Government reserves the right to require that the work be corrected of deficiencies or be redone if corrections cannot be made acceptable or are too extensive to economically correct. Any part of the work that is redone shall be at the Contractor's expense. All work related records shall be available at all times for examination by the COR. The Contractor shall provide all necessary facilities for such inspection during Contractor's regular working hours. It should be clearly understood, except as otherwise provided in these specifications, that such progress inspection shall not constitute acceptance by the Government of any part of the work, but will be for the purpose of coordination and assistance in interpretation of specifications and technical requirements.

2. FINAL INSPECTION AND ACCEPTANCE

   a. Final inspection and acceptance will be accomplished by the Government after the system is completely installed and its operational capabilities verified.

   b. The Contractor shall have an authorized person at the site. The Contractor shall be notified in writing within ten (10) days of final acceptance by the COR.

SECTION F

DELIVERIES OR PERFORMANCE

1. PLACE OF DELIVERY:

The Contractor shall ship and deliver all materials for transhipment to:

Channel Islands National Park
1901 Spinnaker Drive
Ventura, CA 93001
Attention: Chief of Maintenance

The NPS shall provide storage for materials which must then be transhipped to Anacapa Island.

The NPS shall assist in transhipping equipment providing equipment is received in storage at least two weeks prior to installation requirements.

2. DELIVERABLE ITEMS

The Contractor shall provide the deliverable items, in accordance with the terms and conditions set forth in Section C.

SOLAR ELECTRIC PHOTOVOLTAIC GENERATING SYSTEM

MANUALS AND ASSOCIATED DOCUMENTS

3. TIME OF DELIVERY/INSTALLATION

a. Delivery is DESIRED by the Government in accordance with the following schedule:

ITEM	DELIVERY TIME
25% Design	30 days ARO
100% Design	60 days ARO
Complete Delivery of Materials for Solar Electric System	120 days ARO
Manuals	120 days ARO
Installation	180 days ARO

If the offeror is unable to meet the above delivery schedule, he may, without prejudice to the evaluation of this proposal, set forth his Proposed Delivery Schedule below but such delivery schedule must not extend beyond the time for delivery called for in the REQUIRED delivery schedule set forth below.

b. Delivery is REQUIRED by the Government in accordance with the following schedule:

ITEM	DELIVERY TIME
25% Design	30 days ARO
100% Design	60 days ARO
Complete Delivery of Materials for Solar Electric System	180 days ARO
Manuals	180 days ARO
Installation	240 days ARO

c. Delivery is proposed by the Contractor in accordance with the following schedule:

ITEM	DELIVERY TIME
25% Design	___ days ARO
100% Design	___ days ARO
Complete Delivery of Materials for Solar Electric System	___ days ARO
Manuals	___ days ARO
Installation	___ days ARO

SECTION G

CONTRACT ADMINISTRATION DATA

1. CONTRACTOR'S INVOICES

a. The Contractor will be paid, upon submission of proper invoices or vouchers, the prices stipulated herein for services rendered and accepted less deductions, if any, as provided herein and upon final inspection and acceptance of the units. The Contractor shall submit an itemized invoice in triplicate to the Contracting Officer. Invoices shall contain the following information: Contract and number, item numbers, description of supplies or services, sizes, quantities, unit prices and extended totals and delivery point.

b. Each invoice furnished shall be addressed to:

National Park Service
450 Golden Gate Avenue
P.O. Box 36063
San Francisco, CA 94102

Attn: Contracting Officer

2. CORRESPONDENCE

Copies of all correspondence and written notices between the COR and the Contractor shall be sent to the cognizant Contracting Officer at the following address:

National Park Service
450 Golden Gate Avenue
P.O. Box 36063
San Francisco, CA 94102

Attn: Contracting Officer

SECTION H

SPECIAL PROVISIONS

1. INTERPRETATION OF CONTRACT: NOTICE OF AMBIGUITIES

   a. This written contract and any and all identified writings or documents incorporated by reference herein or physically attached hereto constitute the parties' complete agreement and no otner prior or contemporaneous agreements either written or oral shall be considered to change, modify or contradict it. Any ambiguity in the contract will not be strictly construed against the drafter of the contract language but shall be resolved by applying the most reasonable interpretation under the circumstances, giving full consideration to the intentions of the parties at the time of contracting.

   b. It shall be the obligation of the Contractor to exercise due diligence to discover and to bring to the attention of the Contracting Officer at the earliest possible time any ambiguities, discrepancies, inconsistencies, or conflicts in or between the specifications and the applicable drawings or other documents incorporated by reference herein. Failure to comply with such obligation shall be deemed a waiver and release of any and all claims for extra costs or delays arising out of such ambiguities, discrepancies, inconsistencies and conflicts.

2. TECHNICAL DIRECTION

   The work shall be conducted under the general technical direction of the COR or his designee. As used herein, "Technical Direction" is direction to the Contractor which requires filling in details or otherwise serving to accomplish the contractual statement of work. Technical Direction may not constitute a new assignment of work or changes to the contract delivery schedule. The absence of the COR shall not relieve the Contractor of any responsibility for the proper execution of the work. No oral statement of any person shall be allowed in any manner or degree to modify or otherwise affect the terms, conditions, and specifications of this contract.

3. CONTRACTING OFFICER'S REPRESENTATIVE

   The COR for this contract will be named at the time of award. He will provide liaison for the contract between the NPS and the Contractor, and is empowered to assign work under the terms hereof to the Contractor. The COR, however, is <u>not</u> authorized to change any of the terms and conditions of the contract.

4. SUBCONTRACTING RESTRICTION

Except as specifically approved in writing, in advance, by tne Contracting Officer, the Contractor shall not subcontract any of the work outlined in this contract. It is contemplated that approval will be given for subcontracting certain phases of the work when, in the opinion of the COR and the Contracting Officer, such subcontracting will not adversely affect tne quality or delivery of tne final product. Requests for approval to subcontract must be made in writing by the Contractor.

5. WAIVER OF CLAIMS FOR EXTRA WORK

a. The Contractor waives any and all claims and expenses due to extra work performed in response to informal directions, suggestions or instructions (oral or written) given by representatives of the Contracting Officer, unless prior to commencing such work, the Contractor; (i) directly notifies tne Contracting Officer of tne extra work, (ii) requests a formal contract modification authorizing such extra work and; (iii) receives written authorization to proceed witn such extra work from the Contracting Officer.

b. "Extra Work" as used herein means the performance of any kind of work or effort or the compliance with any delivery schedules not required by the contract.

c. "Claims and Expenses" as used herein means those claims and expenses relating to such extra work, and those relating to any acceleration, delays or disruptions caused by the extra work.

6. NOTICE TO THE GOVERNMENT OF DELAYS

In the event the Contractor encounters difficulty in meeting performance requirements, or when he anticipates difficulty in complying with the contract delivery schedule or date, or whenever the Contractor nas knowledge tnat any actual or potential situation is delaying or tnreatening to delay the timely performance of this contract, the Contractor shall immediately notify tne Contracting Officer and the COR in writing, giving pertinent details; provided however, that this data shall be informational only in character and that this provision shall not be construed as a waiver by the Government of any delivery schedule or date or of any rights or remedies provided by law or under this contract.

7. COMMERCIAL WARRANTY

The Contractor agrees that tne supplies or services furnisned hereunder shall be covered by the most favorable commercial warranties the Contractor gives to any customer for the same or similar supplies or services and tnat the rights and remedies provided nerein are in addition to and do not limit any rights afforded to tne Government by any other clause of this Agreement.

8. MATERIALS, WORKMANSHIP AND CONSTRUCTION

The items to be furnished hereunder shall be completely assembled and tested. All materials, parts and equipment furnished under these specifications shall be new, unused and of the latest design and recent manufacture. Workmanship shall be of the highest grade and quality. The component parts of the equipment need not be the product of the same manufacturer.

9. CONTRACTOR GENERATED MATERIAL

All material generated by the Contractor hereunder is the property of the Government and shall be delivered to the Government upon completion of the contract. No Contractor-generated material shall be made available or sold to any requesting Government or private activity without the express written approval of the Contracting Officer of the ordering Agency.

20. SOLICITATION TERMINOLOGY

As Part I, entitled the "Schedule" and Part II, entitled "General Provisions", are expected to form the Schedule and General Provisions of the resulting contract, they are written as contract terms. For purposes the successful Contractor and the word "Contract" to mean any contract resulting from this solicitation.

21. POINT OF CONTACT

As a prospective offeror, you are cautioned against contacting technical personnel of the National Park Service in regard to this RFP prior to any contract award under this solicitation. Such a contact, when verified, may result in nonconsideration of an offeror's proposal. Accordingly, all communications prior to award must be directed to Diana L. Heacock at 556-2480 .

22. PRE-PROPOSAL CONFERENCE

A pre-proposal conference will be held at 9:00 a.m. on 02/24/82 , at the National Park Service to answer questions concerning this RFP. The location of the pre-proposal conference can be obtained by contacting Diana L. Heacock at 556-2480.

23. INSTRUCTIONS FOR SUBMISSION OF PROPOSALS

GENERAL INFORMATION

a. The Government is under no obligation to award a contract nor to pay any costs incurred in the submission of a proposal, or costs incurred in making necessary studies or designs for the preparation thereof, nor to procure or contract for the services or supplies. The Government reserves the right to reject any or all proposals. Contracts from this solicitation may be awarded without discussion of proposals received or with limited discussion; therefore, proposals should be submitted in the most favorable terms from a price and technical standpoint. The Contracting Officer may consider the original proposal as final without extending the privilege to modify or review the proposal or conduct further negotiations.

b. Unnecessarily elaborate brochures or other presentations beyond that sufficient to present a complete and effective proposal are not desired and may be construed as an indication of the offeror's lack of cost consciousness. Elaborate art work, expensive paper and bindings, expensive visual and other presentation aids are neither necessary nor wanted.

c. Any resultant contract shall be made in accordance with Federal Procurement Regulation 1-3.4 entitled "Types of Contracts" and 1-15 entitled "Contract Cost Principles and Procedures." Proposals must set forth full, accurate, and complete information as required by this Request for Proposals (including attachments). The penalty for making false statements is prescribed in 18 USC 1001.

24. INSTRUCTIONS FOR PREPARATION OF PROPOSALS

a. These instructions establish the acceptable minimum requirements for the format and content of proposals.

b. The proposal should be submitted in two (2) parts; a technical proposal and a business management (price) proposal. Each of the parts shall be separate and complete in itself so that evaluation of one part may be accomplished independently of, and concurrently with, evaluation of the other part.

c. An original and three (3) copies of your complete proposal, signed by an official authorized to bind your organization contractually, shall be submitted not later than 4:00 p.m., local time, on or before 03/10/82 .

d. Recommended Proposal Presentation

All documents required for responding to this RFP should be placed in the following order when submitting proposals:

(1) Cover page - with RFP title, number and name of organization. Also indicate on cover page whether it is the signed original or a copy of the proposal.

(2) Technical Proposal

(3) Business Management Proposal

e. Technical Proposal Instructions

(1) The evaluation factors and assigned weights which will be used in the technical review of proposals are set forth in Section M of this RFP. Your proposal should be organized in such a manner to reflect your responsiveness to these factors.

(2) The proposal must demonstrate understanding of the requirement and state how the offeror proposes to provide the specified services. The proposal should also include, as a minimum, the following information:

(a) history and experience of your organization, particularly as it relates to the requirements of this solicitation;

(b) description of offeror's organizational structure, emphasizing the flow of authority to and within the area responsible for performance and administration of any resultant contract (an organizational chart is suggested for inclusion); and

(c) supporting documentation.

(i) Equipment list/information

The offeror shall provide a complete list of all equipment to be provided including components, accessories, hardware, insulation, solder, etc., indicating quantities and maximum operating temperatures when applicable for installation and operation of each system.

(ii) Material availability

The offeror shall certify in writing that the materials and equipment to be supplied have been successfully used commercially for a period of not less than one (1) year prior to the issuance date of this RFP; and are the products of manufacturers regularly engaged in the manufacture of such products.* Items of equipment shall be supported by service organization where specified.

(iii) Certifications

The offeror shall verify that certification of the module acceptance requirements of 5260-5 "Solar Cell Module Design and Acceptance" (page 3-4) shall accompany all modules to be used during system installation.

(iv) System sizing procedures

The offeror shall submit system design performance calculations based on an average load of 1000 watts, 7/days/week. The solar input data for calculations shall include:

* Total Hemisperic
Mean Daily Solar Radiation

Month	BTU/FT2	KJ/M2	Langleys
JAN	927.2	10523.0	251.5
FEB	1219.9	13845.0	330.9
MAR	1635.7	18564.0	443.7
APR	1951.0	22142.0	529.2
MAY	2018.0	22902.0	547.4
JUN	2054.6	23317.0	557.3
JUL	2118.3	24041.0	574.6
AUG	1934.9	21959.0	524.8

*The above is for Pt. Magu, California

* Total Hemisperic
Mean Daily Solar Radiation

Month	BTU/FT2	KJ/M2	Langleys
SEP	1607.7	18246.0	436.1
OCT	1296.1	14709.0	351.6
NOV	1006.4	11421.0	273.0
DEC	856.2	9717.0	232.2
ANN	1552.2	17616.0	421.0

*The above is for Pt. Magu, California

(v) Manuals

Manuals, as described in Section C, shall be provided to describe the installation, operation and maintenance of the DHW systems. These manuals may be separate or included in a composite document.

Failure of this information to be submitted as part of your proposal may result in the rejection of your proposal, except that if transmitted by mail and is received late, it may be considered under provisions for considering late proposals as set forth elsewhere in this Request for Proposal.

f. Business Proposal Instructions

(1) The Business Management Proposal shall include the following:

(a) Completed Representations and Certifications, Section K hereof;

(b) Complete prices inserted in the blanks provided in Section B hereof; and

(c) Complete OF 59 entitled "Contract Pricing Proposal" (Attachment C). Documentation shall include the following.

PER SYSTEM COST ELEMENTS	COST
Solar Cell Modules	_____
Solar Cell Frames & Mounting Stands	_____
Solar Cell Base	_____
Battery Storage System	_____

Batteries _____

Inverter _____

Power Conditioning Equipment _____

Load Management Switching Equipment _____

(2) Any exceptions or proposed conditions to the business or cost aspects of this RFP shall be stated separately and attached to the items specified in (1) above.

25. ALTERNATE PROPOSALS

You may, at your discretion, submit alternative proposals, or proposals which deviate from the requirements. Such proposals may be considered if overall performance would be improved or not compromised and if they are in the best interests of the Government. Alternative proposals, or deviations from any requirement of this RFP, shall be clearly identified.

26. CAPABILITY SURVEY

If a proposal submitted in response to this solicitation is favorably considered, a pre-award survey team may contact/visit an offeror's facility to determine financial and technical ability to perform under a contract. Current financial statements and other pertinent data should be available at that time.

27. NOTICE OF APPLICABLE SMALL BUSINESS SIZE STANDARD: NON SET-ASIDE

The following produce or service classification code and small business size standard applies to this procurement;

Item No.	Classification Code	Size Standard
All items	3433	500 people (from FPR 1-1.701-1 (h))

28. TYPE OF CONTRACT

A firm fixed price contract is anticipated to be awarded as a result of this solicitation.

29. USE AND DISCLOSURE OF PROPOSAL INFORMATION

(a) Definitions. For the purposes of this provision and the Freedom of Information Act (5 U.S.C. 552), the following terms shall have the meaning set forth below:

(1) "Trade Secret" means an unpatented, secret, commercially valuable plan, appliance, formula, or process, which is used for the making, preparing, compounding, treating or processing of articles or materials which are trade commodities.

(2) "Confidential commercial or financial information" means any business information (other than trade secrets) which is exempt from the mandatory disclosure requirement of the Freedom of Information Act, 5 U.S.C. 552. Exemptions from mandatory disclosure which may be applicable to business information contained in proposals include exemption (4), which covers "commercial and financial information obtained from a person and privileged or confidential," and exemption (9), which covers "geological and geophysical information, including maps, concerning wells."

(b) If the offeror, or its subcontractor(s), believes that the proposal contains trade secrets or confidential commercial or financial information exempt from disclosure under the Freedom of Information Act, (5 U.S.C. 552), the cover page of each copy of the proposal shall be marked with the following legend:

The information specifically identified on pages of this proposal constitutes trade secrets or confidential commercial and financial information which the offeror believes to be exempt from disclosure under the Freedom of Information Act. The offeror requests that this information not be disclosed to the public, except as may be required by law. The offeror also requests that this information not be used in whole or part by the Government for any purpose other than to evaluate the proposal, except that if a contract is awarded to the offeror as a result of or in connection with the submission of the proposal, the Government shall have the right to use the information to the extent provided in the contract.

(c) The offeror shall also specifically identify trade secret information and confidential commercial and financial information on the pages of the proposal on which it appears and shall mark each such page with the following legend:

This page contains trade secrets or confidential commercial and financial information which the offeror believes to be exempt from disclosure under the Freedom of Information Act and which is subject to the legend contained on the cover page of the proposal.

(d) Information in the proposal identified by an offeror as trade secret information or confidential commercial and financial information shall be used by the Government only for the purpose of evaluating the proposal, except that (i) if a contract is awarded to the offeror as a result of or in connection with submission of the proposal, the Government shall have the right to use the information as provided in the contract, and (ii) if the same information is obtained from another source without restriction it may be used without restriction.

(e) If a request under the Freedom of Information Act seeks access to information in a proposal identified as trade secret information or confidential commercial and financial information, full consideration will be given to the offeror's view that the information constitutes trade secrets or confidential commercial or financial information. The offeror will also be promptly notified of the request and given an opportunity to provide additional evidence and argument in support of its position, unless administratively unfeasible to do so. If it is determined that information claimed by the offeror to be trade secret information or confidential commerical or financial information is not exempt from disclosure under the Freedom of Information Act, the offeror will be notified of this determination prior to disclosure of the information.

(f) The Government assumes no liability for the disclosure or use of information contained in a proposal if not marked in accordance with paragraphs (b) and (c) of this provision. If a request under the Freedom of Information Act is made for information in a proposal not marked in accordance with paragraphs (b) and (c) of this provision, the offeror concerned shall be promptly notified of the request and given an opportunity to provide its position to the Government. However, failure of an offeror to mark information contained in a proposal as trade secret information or confidential commercial or financial information will be treated by the Government as evidence that the information is not exempt from disclosure under the Freedom of Information Act, absent a showing that the failure to mark was due to unusual or extenuating circumstances, such as a showing that the offeror had intended to mark, but that markings were omitted from the offeror's proposal due to clerical error.

Editorial Comment

In the following Section M, Evaluation Factors for Award, typical point values assigned to the various evaluation criteria are given. It is recommended that these values not be revealed to the prospective bidders since they can bias the responses to the request-for-proposal. The result is that those criteria with the higher point values are unduly emphasized at the expense of the other criteria. If desired, the evaluation criteria can be arranged in order of value with the top value criterion appearing first.

SECTION M

EVALUATION FACTORS FOR AWARD

1. The contract resulting from this solicitation will be awarded to that responsible offeror whose offer, conforming to the solicitation, is determined most advantageous to the Government, price and other factors considered. Due to the interrelationship of the system only one award will be made. A technical evaluation will be performed on each offeror's technical proposal based solely on the information furnished and not on previous knowledge or associations.

2. The Government may award a contract, based on initial offers received, without discussion of such offers. Accordingly, each initial offer should be submitted on the most favorable technical standpoint which the offeror can submit to the Government.

3. A point system will be used in the evaluation of technical proposals. The evaluation criteria and the point values for each category are as follows:

a.	Approach to project and overall quality of proposal, to include:		100 points
	(1) Offeror's overall technical approach to project implementation;	35 points	
	(2) Completeness and extent of details of submittals;	25 points	
	(3) Offeror's proposed systems materials;	20 points	
	(4) Offeror's proposed system thermal electric capabilities;	20 points	
b.	Current and previous organizational experience, to include:		20 points
	(1) General experience in managing and and implementing solar field programs, and	10 points	
	(2) Specific experience with managing solar programs of the type proposed.	10 points	
c.	Ability to meet "desired" Delivery Schedule;		30 points

4. Between acceptable proposals with a significant difference in technical weighting, total cost to the Government shall be considered important in making a determination as to which proposal offers the greatest value to the Government. Between substantially equal technical proposals, the proposed prices will become the major factor in selection of a proposal for award.

APPENDIX B

SAMPLE TECHNICAL EXHIBITS OF REQUEST-FOR-PROPOSAL FOR MILITARY PHOTOVOLTAIC APPLICATIONS

CONTRACT NO F26600-81- C0048

PART III - LIST OF DOCUMENTS, EXHIBITS AND ATTACHMENTS

EXHIBIT J1

CONTRACT DATA REQUIREMENTS LIST

SYSTEM/ITEM Photovoltaic Power Systems

TO CONTRACT/PRK F26600-81-C0048

CATEGORY Engineering Data

CONTRACTOR

1. SEQUENCE NUMBER	2. TITLE OR DESCRIPTION OF DATA / 3. SUBTITLE	6. TECHNICAL OFFICE	10. FREQUENCY	12. DATE OF 1ST SUBMISSION	14. DISTRIBUTION AND ADDRESSEES (Addressee—Regular Copies/Repro Copies)	
4. AUTHORITY (Data Item Number)	5. CONTRACT REFERENCE	7. DOD200 REQ / 8. App Code (A) / Input to IAC (E)	11. AS OF DATE	13. DATE OF SUBSEQUENT SUBM/EVENT ID		
1. A001	2. Performance Verification Test Procedure 3.	6. 554RG/EN	10. Blk 16	12. Blk 16	14. 554 RG/EN Nellis AFB NV 89191 TFWC/LGCCA DCASMA BALT	1/0 Ltr of trans Ltr of Trans
4. UDI-T-20538	5. 4.5	7. LT / 8. A / 9.	11.	13.		15. TOTAL 1/0
16. REMARKS a. Thirty (30) days prior to testing of first article system. b. Test for first article and eight production systems 30 days prior to delivery.						
1. A002	2. Operational/Performance Test Report 3.	6. 554RG/EN	10. 1 Time	12. Blk 16	14. 554RG/EN Nellis AFB NV 89191 TFWC/LGCCA DCASMA BALT	1/0 Ltr of trans Ltr of trans
4. UDI-T-23740	5. 3.5	7. LT / 8. A / 9.	11.	13.		15. TOTAL 1/0
16. REMARKS Thirty (30) days prior to delivery of first article system.						
1. A003	2. Contractor's Progress and Status Report 3.	6. 554RG/EN	10. Monthly	12. 30 days	14. 554 RG/EN Nellis AFB NV 89191 1 Ea. Repro 1 Ea. Regular DCASMA BALT	 Cy 1/0 Cy 1/0 1/0
4. UDI-A-22050B	5. 3.6	7. LT / 8. A / 9.	11. 10th ea mo	13.		15. TOTAL 3/0
16. REMARKS Monthly status reporting with one final report at completion of project. Final report to include originals of photographs.						
1. A004	2. Drawings 3.	6. 554RG/EN	10. Blk 16	12. Blk 16	14. 554RG/EN Nellis AFB NV 89191 TFWC/LGCCA DCASMA BALT	8/1 Ltr of trans Ltr of trans
4. DI-E-5325	5. 3.6	7. LT / 8. A / 9.	11.	13. * Vellum		15. TOTAL 8/1
16. REMARKS a. One set of reproducible*drawings and five sets of reproduced drawings shall be submitted at design completion (100 days after contract award). b. Three sets of reproduced drawings shall be submitted at 60% design completion (30 days after contract award).						

PREPARED BY: JOHN R. HARRIS, GS-12, Mechanical Engineer — DATE: 6 May 80

APPROVED BY: Herbert Craig — DATE: MAY 6 1980

DD FORM 1 JAN 79 1423

CONTRACT DATA REQUIREMENTS LIST

EXHIBIT J1 | CATEGORY Engineering Data | SYSTEM/ITEM Photovoltaic Power Systems

TO CONTRACT/PR F26600-81-C0048 | CONTRACTOR

1. SEQUENCE NUMBER	2. TITLE OR DESCRIPTION OF DATA / 3. SUBTITLE	4. AUTHORITY (Data Item Number)	5. CONTRACT REFERENCE	6. TECHNICAL OFFICE	7. DOD/SSO REQ	8. APP CODE (A)	9. INPUT TO IAC (N)	10. FREQUENCY	11. AS OF DATE	12. DATE OF 1ST SUBMISSION	13. DATE OF SUBSEQUENT SUBM/EVENT ID	14. DISTRIBUTION AND ADDRESSEES (Addressee – Regular Copies/Repro Copies)	15. TOTAL
A005	Contractor Operations and Maintenance Orientation Program	Technical Exhibit RG-80-B	4.11	554RG/EN	LT	A		1 Time		Blk 16		554RG/EN Nellis AFB NV 89191	2/0
A006	Operations and Maintenance Manual	Technical Exhibit RG-80-A	4.10	554RG/EN	LT	A		Blk 16		Blk 16		554RG/EN Nellis AFB NV 89191 TFWC/LGCCA DCASMA BALT	1/0 Ltr of trans Ltr of trans
A007	Preliminary Design	Technical Exhibit RG-80-C	4.2	554RG/EN	LT	A		1 Time		Blk 16		554RG/EN Nellis AFB NV 89191 TFWC/LGCCA DCASMA BALT	5/0 Ltr of trans Ltr of trans

16. REMARKS

A005: Furnished 30 days prior to delivery of production units.

A006: A preliminary manual shall be delivered concurrently with the First Article system. Approved manuals shall be delivered concurrently with each produced system.

A007: Presented during Design Review Conference 30 days after contract award.

15. TOTAL	
A005	2/0
A006	1/0
A007	5/0

PREPARED BY: JOHN R. HARRIS, GS-12, Mechanical Engineer | DATE: 6 May 80 | APPROVED BY: Herbert Craig | DATE: MAY 6 1980

DD FORM 1 JAN 79 1423

DATA ITEM DESCRIPTION	2. IDENTIFICATION NO(S)	
	AGENCY	NUMBER
TITLE PERFORMANCE VERIFICATION TEST PROCEDURE	NAVY-OS	UDI-T-20538

DESCRIPTION/PURPOSE

The Performance Verification Test Procedure is used to set forth the means for determining compliance with the applicable performance specification requirements of XWS 13751, dated Dec 1, 1973, and XWS 14445, dated Dec 1, 1973, for preproduction equipments.

4. APPROVAL DATE: 73 June 5

5. OFFICE OF PRIMARY RESPONSIBILITY: NUSC

6. DDC REQUIRED:

7. APPROVAL LIMITATION: Limited to OJ-326/IP-1181 console procurement

APPLICATION/INTERRELATIONSHIP

8. REFERENCES (Mandatory as cited in Block 10)

XWS13751
XWS14445

MCSL NUMBERING

9. PREPARATION INSTRUCTIONS

10. Unless otherwise indicated in the contract, documents cited in this block of the issue in effect on the date of invitation for bids or request for proposals or quotations, form a part of this Data Item Description to the extent specified herein.

10.2 The Performance Verification Test Procedure describes the tests that are to be used as performance verification criteria for equipments being delivered. The procedure shall be geared to demonstrate conformance to the requirements specified within the performance specification.

10.3 The procedure shall contain the following information:

a. Scope. This section is to contain a brief statement which defines the purpose for the procedure.

b. Applicable Documents. This section is to contain a list of all documents referenced or specified in the procedure.

c. Prerequisities. This section is to include the following:

1. Inspection requirements prior to test.
2. Disposition of any deviations resulting from inspection.
3. Precalibration requirements/certification.

DD FORM 1664

DATA ITEM DESCRIPTION -Cont'd	IDENTIFICATION NO(S)	
	AGENCY	NUMBER
TITLE PERFORMANCE VERIFICATION TEST PROCEDURE	NAVY-OS	UDI-T-20538

10.3 (continued)

d. Services Required. This section is to contain statement of services required (e.g., electrical power, water, etc.) and a record of actual conditions.

e. Installation Precaution. This section is to define special grounding or mechanical anchoring requirements.

f. Area Designator. This section is to contain a figure or other reference data defining locations of the equipment applicable to the test.

g. Test Requirements:

1. General. This section is to contain a resume of the requirements as specified in the contractual documents and associated specifications. Reference should be made herein to those definitive objectives of the acceptance test.

2. Test Equipment. This section is to contain a list of all test equipment required to accomplish the test, correlated with the function it is to perform. The calibration cycle of the equipment used and the accuracy of the equipment shall be specified.

3. Test Conditions. This section is to contain:

(a) the environmental conditions under which the tests are to be conducted and the tolerance on the test conditions,
(b) The test configuration including a sketch or drawing of the articles mounting position during the test,
(c) If applicable, the frequency increments at which the test is to be performed,
(d) If applicable, the power being applied to the article under test, and
(e) The test sequence.

4. Detailed Procedures. This section is to include a detailed step-by-step procedure of exactly how each test identified (or referenced) in paragraph 7.a is to be performed

h. Accept-Reject Criteria. This section is to include criteria extracted from the applicable Procurement Specification for determining whether or not the article successfully passed the test.

i. Definition. This section is to contain definitions and abbreviations, if applicable.

j. Test Data Sheets. This section is to contain data sheets for reporting the results of the tests, normally combined with item 8.

k. Certification. This section is to include a certification statement required on each data sheet and the title of the persons and/or organizations who must sign the certification.

The procedure shall be prepared in contractor's format, using good commercial practices.

DATA ITEM DESCRIPTION	2 IDENTIFICATION NO(S)	
	AGENCY	NUMBER
1 TITLE REPORT, OPERATIONAL/PERFORMANCE TEST	NAV-SHIPS	UDI-T-23740

3 DESCRIPTION/PURPOSE
This report will present the intermediate and final results of the operation/performance tests required by the contract. These results will provide information to the cognizant engineer to enable him to determine acceptance or rejection of the equipment/commodity.

4 APPROVAL DATE
72 APRIL 01

5 OFFICE OF PRIMARY RESPONSIBILITY
SHIPS 0125

6 DDC REQUIRED

7 APPLICATION/INTERRELATIONSHIP
This DID may be applied whenever Operational/Performance tests are required by the contract.

8 APPROVAL LIMITATION

9 REFERENCES (Mandatory as cited in Block 10)

MCSL NUMBER(S)

10 PREPARATION INSTRUCTIONS

1. The report shall be typed in the contractors' format and shall present the results of each test or other action performed and/or evaluated for the purpose of demonstrating the operation/performance of the system, subsystem, equipment, and/or any of its constituent elements.

2. The report shall specifically contain:

(a) Test article identification and full description of test specimens utilized, including any deviations from the approved configurations.

(b) Date and geographic location of test or demonstration.

(c) Statement of test objectives, including type, unit of measure quantitative goals/requirements to be demonstrated, mode of operation, operating time downtime, causes therefor, corrective action, and maintenance required.

(d) Statistical confidence calculations, if appropriate.

(e) Discussion of methods and conditions of the test, including methods of evaluating the data obtained and comparison of the conditions with those anticipated in ultimate deployment and use of the contract item.

(f) Results obtained, including specific identification and discussion of objectives.

DD FORM 1664

DATA SET CONTINUATION SHEET

TITLE	CONTROL NO.
REPORT, OPERATIONAL/PERFORMANCE TEST	UDI-T-23740

10. Preparation Instructions (continued)

(g) Contractor's conclusions, corrective action anticipated, recommendations to correct deficiencies, and suggested improvements based on evaluation of the test/demonstration results demonstrated satisfactorily and those not demonstrated satisfactorily.

(h) Drawings, sketches, photographs, calculations or other attachments that will clarify or explain the text.

3. The report shall contain the following sections as a minimum:

(a) Data collected.

(b) Factors which influence the data.

(c) Analysis of the data.

(d) Results of the demonstration.

(e) Assessment of qualitative and quantitative factors.

(f) Deficiencies.

(g) Recommendations:

(1) To correct deficiencies.
(2) For suggested improvements.

(h) Results of retest (if applicable).

DATA ITEM DESCRIPTION	2. IDENTIFICATION NO(S)	
	AGENCY	NUMBER
1. TITLE REPORT, CONTRACTOR'S, PROGRESS AND STATUS	NAVY-EC	UDI-A-22050B

3. DESCRIPTION/PURPOSE

Contractor's report indicating work progress, status of assigned tasks, and, if applicable, cost reporting.

4. APPROVAL DATE
1 Jul 76

5. OFFICE OF PRIMARY RESPONSIBILITY
PME-124

6. DOC REQUIRED

8. APPROVAL LIMITATION

7. APPLICATION/INTERRELATIONSHIP

Report shall be used to evaluate and guide progress, and to maintain cognizance of cost.

9. REFERENCES (Mandatory as cited in Block 10)

MCSL NUMBERS

10. PREPARATION INSTRUCTIONS

10.1 The Contractor's Progress and Status Report (Including Cost Reporting) shall be typewritten on approximately 8 x 10½" white paper, securely stapled on left margin. Report shall include, but is not limited to, the following:

a. Contractor's name and address.
b. Contract Number.
c. Date of report.
d. Title.
e. Serial Number of report.
f. Period covered by report and identification of which contract phases are covered, if applicable.
g. Description of progress made during period reported, including problem areas encountered, and recommendations, if any, for subsequent solution beyond scope of this contract.
h. Results obtained related to previously identified problem areas.
i. Manhours expended for the reporting period, and cumulatively during the contract.
j. Cost curves, if applicable, portraying actual/projected conditions through contract.
k. If applicable, cost incurred for the reporting period and total contractual expenditures as of reporting date.
l. Trips and significant results, if applicable.
m. Contract schedule status.
n. Summary of Engineering Change Proposals (ECP status, including identification of those proposed, those approved, and those implemented.

DD FORM 1 JUN 68 1664 S/N-0102-019-4000

Data Item Description (Continued)	Identification No. (s)	
	Agency	Number
Title REPORT, CONTRACTOR'S, PROGRESS AND STATUS	NAVY-EC	UDI-A-22050B

o. Plans for activities during the following period, if applicable.

p. Name of person(s) preparing report, including telephone number.

DATA ITEM DESCRIPTION	2. IDENTIFICATION NO(S)	
	AGENCY	NUMBER
1. TITLE Engineering Drawings (Commercial)	NSA	DI-E-5325

3. DESCRIPTION/PURPOSE

To obtain the complete set of engineering data prepared by the contractor to develop, manufacture, test, install and maintain components, equipments, systems.

4. APPROVAL DATE
6 October 1972

5. OFFICE OF PRIMARY RESPONSIBILITY
NSA- D

6. DDC REQUIRED
N/A

7. APPLICATION/INTERRELATIONSHIP

Provide support data for replacement, installation, test and maintenance of commercially produced end items or components of items.

8. APPROVAL LIMITATION
N/A

9. REFERENCES (Mandatory as cited in block 10)

MCRL NUMBER(S)
N/A

10. PREPARATION INSTRUCTIONS

1. Prepare reproducible copies of the complete set of engineering drawings and associated data used to manufacture, test, install and maintain the delivered item(s) and components of these items. The complete set shall include all referenced company standards, processes, procedures, test specifications and a definition of all symbols, codes, reference designators, etc., which do not conform to industry or government standards.

2. The drawings and data shall reflect the exact configuration of the equipment/system delivered to the procuring activity.

3. The contractor's standard drawing practices apply, unless otherwise directed by the DD 1423.

DD FORM 1 JUN 68 1664

*U.S. GOVERNMENT PRINTING OFFICE: 1974—713-160/2921

554 OPERATIONS SUPPORT WING

554 RANGE GROUP

NELLIS AFB, NEVADA

TECHNICAL EXHIBIT RG-80-B

CONTRACTOR OPERATIONS & MAINTENANCE ORIENTATION PROGRAM

30 APRIL 1980

1. SCOPE

1.1 Purpose. This Technical Exhibit covers the requirements for contractor orientation. The contractor shall furnish an orientation program for the applicable system which is being supplied to the Air Force in accordance with the contract and this specification. In general, this orientation shall be of the on-the-job (OJT) type, designed to orient maintenance and operations personnel with the normal characteristics of the equipment supplied.

1.2 Coverage. The OJT orientation should include the following subjects.

1.2.1 Block diagram. A general block diagram description of the system and the portion of any associated equipment that affects or is affected by this equipment should be provided.

1.2.2 Theory of operation. The theory of operation should be presented in a clear concise manner. It is highly desirable that simplified data flow diagrams of signal and functional loops, simplified schematics, timing diagrams, and waveform diagrams with voltage levels be included if available. It should be considered that the trainee will be a typical electronics technician with a two year technical Trade School education (or military equivalent) and with two to four years experience on related equipment.

1.2.3 Operating and checkout procedures. The manufacturer's recommended checkout and operating procedures, including all calibration and adjustments, shall be provided.

1.2.4 Preventive maintenance. This shall include the manufacturer's recommended procedures and checks as deemed necessary for preventive maintenance. Manufacturer's specifications, including tolerances, for all electrical, mechanical, or other applicable measurements or adjustments should be included if available.

1.2.5 Special test equipment. The operation of special test equipment shall be demonstrated during the OJT.

1.2.6 Operating experience. Supervised OJT shall be included to give the student practical experience in operating, troubleshooting, checkout procedures and alignment.

2. DOCUMENTATION

2.1 Orientation materials. The contractor should provide each trainee with appropriate shematics, drawing, engineering notes, etc., as available to supplement the instruction.

3. ORIENTATION OPERATIONS

3.1 Orientation location. Nellis Air Force Base, Area III may be used as the site for orientation unless otherwise specified in the contract schedule.

554 OPERATIONS SUPPORT WING

554 RANGE GROUP

NELLIS AFB, NEVADA

TECHNICAL EXHIBIT RG-80-A

OPERATIONS & MAINTENANCE MANUAL

30 APRIL 1980

1. SCOPE

1.1 Purpose. This Technical Exhibit covers requirements for Commercial Manufacturer's Manuals on equipment to be supplied under contract. The contractor shall prepare a typewritten or printed manuscript for a total system technical manual in accordance with the following requirements.

2. MANUSCRIPT FORMAT

2.1 Arrangement. The Manufacturer's arrangement and format now in use for existing commercial publications is satisfactory. Manuals should have a Table of Contents, List of Tables, and List of Illustrations.

2.2 Illustrations and Schematic Diagrams. Illustrations, logic diagrams, data flow, and simplified schematics are required. This material should be located as close as possible to the written material which it supplements. Complete schematic and wiring diagrams shall be furnished for all contractor-supplied equipment, and unless they are included in the Manufacturer's publications provided, shall be supplied as required materials.

3. CONTENT

3.1 General Description. A section of each publication should be devoted to a general description of the equipment and should also include all information necessary to describe the basic use or function of the equipment group, unit, or both. This should include a general "block diagram" presentation and a tabular listing of the applicable physical and electrical characteristics of the equipment. If auxiliary equipment is required, tabular charts should be included, listing such equipment.

3.2 Theory of Operation. A section should describe the theory of operation of the system in a clear, concise manner supported by simplified schematics, logic, data flow diagrams, one-function diagrams, etc. Timing and waveform diagrams and voltage levels should be shown as required. Where the design allows operation in a number of different modes, an operational description of each model should be included.

3.3 Operating Procedures. Copies of operating procedures, comparable in quality to the best commercially available, shall be provided for each equipment. This section should present in simple, clear language the routine of operation, form necessary preparations for placing the equipment into operation to securing the equipment after operation. This section may also contain appropriate illustrations, with the sequence of operations presented in tabular form wherever feasible. This section shall also contain a list of applicable test instruments and tools required in the performance of necessary measurements and techniques.

3.4 Preventive Maintenance. Instruction Manuals should specify the manufacturer's recommended procedures and checks necessary for preventive maintenance.

3.5 Corrective Maintenance. Where applicable, a section should provide data necessary for isolation and repair of failures or malfunctions. General instructions should be included for disassembly, overhaul, and reassembly, including shop specifications of performance requirements.

3.6 Installation. This section should contain a detailed physical description of size, weight, special mounting requirements, electrical connections, and all other pertinent information necessary for proper installation and use of the system. If required, instructions should be given for uncrating, unpacking, placement, etc. If special procedures are necessary for removal, packing and shipment, they should also be described.

3.7 Parts List. A complete parts list shall be provided. A recommended spare parts inventory derived from the parts list and representing those parts necessary for anticipated maintenance and repair of the delivered systems shall be provided. This inventory shall include quantity, identification and current prices. Should the Government option to purchase the spare parts inventory, either partially or completely, the contractor shall provide the parts at the quoted prices.

4. FINAL DELIVERY

4.1 Manual Volumes. Manuals should be self-contained insofar as practicable.

4.2 Manual Processing. Manuals shall be processed in the form normally supplied for commercial use.

554 OPERATIONS SUPPORT WING

554 RANGE GROUP

NELLIS AFB, NEVADA

TECHNICAL EXHIBIT RG-80-C

PRELIMINARY DESIGN

30 APRIL 1980

1. SCOPE

1.1 Purpose. This Technical Exhibit includes the contractor's requirement for preliminary design submittals. The contractor shall furnish a preliminary design to the Air Force in accordance with the contract and this specification.

1.2 Drawings. The contractor shall provide drawings to support the content of the preliminary design. Drawings shall be sufficiently detailed to clearly illustrate the concepts of the preliminary design.

1.3 Analysis. The contractor shall provide a detailed analysis including those assumptions, criteria and rationale used to develop the design. The analysis shall provide the documentation that those performance criteria included in these exhibits are satisfied.

2. DOCUMENTATION

2.1 Format. A simplified format with brief narratives including summarized design calculations shall be provided and presented on 8½ x 11 inch sheet paper. Design calculations may be handwritten provided they are neat and legible.

2.2 Presentation. The contractor shall present the preliminary design to Government personnel during a Preliminary Design Review Conference.

SPECIFICATION SHEET - AFAPL 79-01

to

SOLAR CELL MODULE DESIGN AND TEST SPECIFICATION
#5260-2 dated 1 Aug 79 (DOE/JPL)

A. SCOPE: This document establishes requirements for terrestrial solar cell modules for use in Air Force applications characterized by low system voltage and remote unattended installations. The requirements of the basic specification - #5260 apply except as noted on this specification sheet.

BASIC SPECIFICATIONS:

1. Section I - Paragraph A(1) - Delete

2. Section I - Paragraph B - add (4) - Design Handbook, Environmental Engineering #AFSCDH 1-5, 10 Mar 1974.

3. Section II - Paragraph A(3) - Delete sentence 2. INSERT: The module supplier shall specify V_{NO} for the specific panel design.

4. Section II - Paragraph B(4) - Delete sentence 2 and subelements. INSERT: The modules shall incorporate a minimum of six parallel cell strings with series/parallel interconnection of cells within the module. Integral bypass diodes may be incorporated in each module.

5. Section II - Add (5) - Modules planned for series interconnection shall be within $\pm$5% of the nominal current rating at standard conditions. Individual series strings of modules may have different current ratings.

6. Section II - Paragraph D - Add (6) - Solar intensity as described Environmental Engineering Design/Handbook 3rd edition, 10 March 1974, #AFSCDH 1-5 (110 - 120 mw/cm^2). Method F.

7. Section IV - Paragraph A.1 - Delete 15.0V_{DC} unless otherwise specified. INSERT: As specified by the module supplier.

8. Section V - Add F - Solar Intensity Test Procedure. The module shall be exposed to simulated AM1 solar intensity of 120 mw/cm^2 in an ambient temperature of 40^{o}C and the panel in short circuit. The test will last for 3 hr duration. Following completion, a complete IV curve will be taken. Variation in any critical parameter, I_{SC}, V_{OC}, P_M of .5% will be considered failure of the test.

EXHIBIT

PHOTOVOLTAIC POWER SYSTEMS FOR
COMMUNICATION SHELTERS ON NELLIS RANGE COMPLEX

1.0 INTRODUCTION: This exhibit defines the requirements and tasks for contractor design, fabrication, assembly and test of photovoltaic power systems to support full-time (24 hours/day) operation of four microwave communication shelters to be installed by the Air Force at various sites within the Nellis North Range complex.

2.0 BACKGROUND: A Nellis Range communications improvement project is in progress which will change out the existing analog microwave equipments. The new microwave equipments will be digital type and will operate from new -24 VDC battery plants. These new battery plants, with associated solar arrays and regulators, are the subject of this exhibit.

3.0 SCOPE: The scope of work includes a complete engineering design and analysis, fabrication, assembly, production, and testing of "turn-key" systems which include:

3.1 Engineering and analysis of the design for four identical photovoltaic systems. The solar photovoltaic modules shall be qualified, or capable of being qualified, to Jet Propulsion Laboratory (JPL) specifications and shall be tested to JPL specifications prior to shipment from the modules manufacturer.

3.2 Conducting factory performance verification testing of the first-article solar array, battery plant, regulator, and monitor subsystems under contractor-generated procedures previously approved by the Air Force.

3.3 Shipping the first-article system to Nellis Air Force Base, Nevada.

3.4 Assembling the first-article solar power system at Nellis AFB Area III and integrating it with a representative communications shelter.

3.5 Conducting initial operational test and evaluation (IOT&E) of the first-article system in the field under a contractor-generated plan previously approved by the Air Force, incorporating any redesign/corrections found necessary to conform to performance criteria and retesting to confirm suitability of the resulting baseline design. After successful completion of the testing, the Air Force will accept this first system and authorize production of the remaining three power systems.

3.6 Furnishing complete documentation packages consisting of operations and maintenance technical manuals and as-built drawings for Air Force approval.

3.7 Conducting initial 3-day orientation course for selected employees of the communications operations and maintenance contractor and certain government representatives.

3.8 Conducting acceptance testing of three production power systems in accordance with the contractor-generated test plan of Section 3.2

3.9 Providing a recommended spares list and priced option for government purchase of selected initial operating spares.

Editorial Comment

It is recommended that in the following Section 4, Contractor Tasks, that a performance warranty be included. An example of a warranty that should be used is as follows:

> It is understood and agreed that the photovoltaic system will be fit for and operate in accordance within the system performance requirements specified in the contract for a period of not less than two years after acceptance by the government. All necessary adjustments occasioned by failures not caused by misuse or accident through fault and negligence by the government shall be made at the contractor's expense; including, without limitation: inspection by the contractor at the installation site; labor; parts; and, transportation costs, if any.

4.0 CONTRACTOR TASKS:

4.1 Contractor, after award, shall perform on-site investigation of certain typical existing communication shelters and range locations. Investigation shall provide sufficient data to design the photovoltaic systems including solar/weather data and specific data for the interfacing of each solar array to the communication shelters.

4.2 Contractor shall provide the design and specification for the four systems. Design shall incorporate provisions for future expansion up to 1500 peak watt capacity.

4.3 Contractor shall design the system to satisfy the following performance criteria:

Current Consumption: 32 amps @ -24 VDC. (Variation -24 VDC to -28 VDC)

Hours of Operation: 24 hours/day.

Locations: See Table 1.

Battery Storage Capacity: 48 hours.

Altitude: 2000-8000 ft mean sea level.

Wind Pressure: 40 PSF.

Ambient Temperature: Range - 30^{o} to 120^{o}F.

Structural Requirements: Compliance with Uniform Building Code. Structure shall be free standing, capable of supporting module assemblies. Structure shall be capable of being supported and anchored without external support (i.e., concrete supporting foundations). All anchors or hold-downs shall be furnished as part of the structure.

Dust Control: Climatic conditions produce an extreme dust environment. System shall be sealed to prevent dust intrusion to critical components.

Height Requirements: No part of the structure shall exceed 16 feet high. Modules shall be no lower than 3 feet above ground level.

Electrical Requirements: The entire system shall conform to the National Electrical Code.

Transportability: Complete assembly must be capable of being transported on a standard 40-ft "lowboy" trailer. Weight and height limitations shall comply with Nevada and local laws and regulations. Partial disassembly will be permitted.

Assembly: System shall be capable of being assembled in remote areas without power tools. Special tools required for assembly/disassembly shall be furnished at the time of delivery with a complete set for each delivered system including prototype.

Maintainability: System shall be capable of being repaired in remote areas without power-assisted tools or special equipment. Major components shall be designed for ease of replacement and repair.

4.4 Contractor shall insure that the photovoltaic modules are qualification-tested to conform to JPL Specification 5260-5, dated August 1, 1979 with addendum AFAPL 79-01 Specification Sheet additions and modifications. Contractor shall use rejection criteria in accordance with JPL Document 5101-21-Revision A, dated June 28, 1977.

4.5 Contractor shall develop a factory performance verification test plan for the first-article system and subsequent three production systems, and submit it to the Contracting Officer for review and approval. Contractor shall coordinate with Government a mutually agreeable date for Government representative to witness factory performance verification tests.

4.6 Following test plan approval, contractor shall conduct factory performance verification tests on the first-article system witnessed by government representatives. Any redesign or corrections found necessary to conform to performance criteria shall be incorporated and the system shall be retested to confirm suitability of the resulting baseline design.

4.7 Contractor shall disassemble and pack, as necessary, then ship the first-article system to Nellis AFB, NV, for delivery to Area III in the vicinity of the main base.

4.8 Contractor shall assemble the first-article system in the designated location within Nellis AFB Area III and connect it to the power cable provided from the representative Air Force communications shelter.

4.9 Contractor shall prepare a field operational test and evaluation (OT&E) plan for the first-article system and submit it to the Contracting Officer for review and approval. The test period will encompass an operational period of at least four weeks (24 hours/day), including a non-sun period simulation to demonstrate the battery plant storage capacity.

4.10 Contractor shall provide complete documentation packages of technical manuals and as-built drawings to the Contracting Officer for review and approval. The manuals shall be in accordance with Technical Exhibit A.

4.11 Contractor shall provide an operations and maintenance orientation course plan, in accordance with Technical Exhibit B, to the Contracting Officer for review and approval.

4.12 Contractor shall conduct the field operational test and evaluation on the first-article system in accordance with the previously approved plan. Any problems that occur shall be analyzed and proposed corrective actions shall be incorporated by the contractor after concurrence by the Air Force. The OT&E will include actual disassembly and assembly demonstration as required to prepare for, and set up after, a photovoltaic system relocation. This demonstration can be scheduled as part of the introduction to the follow-on maintenance orientation course.

4.13 Contractor shall conduct a 3-day maintenance orientation course, using previously approved technical manuals and drawings, for selected Government representatives and employees of the range communications operations and maintenance contractor. The course will cover theory of operation and preventive maintenance of all subsystems and troubleshooting to the lowest level which can normally be accomplished by contractor O&M personnel.

4.14 Contractor shall furnish three production systems delivered, assembled, installed and functionally tested at Nellis AFB, NV, Area III. All systems shall be tested at the factory before shipment in accordance with the procedures previously approved in para 4.5 above.

1 Atch
Table 1

TABLE 1

LOCATION OF COMMUNICATION VANS

COMM VANS	PEAK WATTS	LATITUDE	LONGITUDE	ELEVATION
1. Relocatable	750	--	--	--
2. Relocatable	750	--	--	--
3. Gold Mtn	750	33°15'10"N	116°34'12"W	6450
4. Site 32/50	750	37°39'25"N	116°42'25"W	5600
5. Site 53	750	37°54'16"N	116°26'26"W	5250
6. Gold Reed	750	37°37'02"N	116°15'51"W	5760
7. Cedar Pipeline	750	37°43'15"N	116°13'13"W	5650
8. Quartz Video	750	37°16'47"N	116°45'22"W	6880
9. Quartz GCI	750	37°16'47"N	116°45'22"W	6880

TECHNICAL REPORT STANDARD TITLE PA

1. Report No. 84-35	2. Government Accession No.	3. Recipient's Catalog No.
4. Title and Subtitle Flat-Plate Photovoltaic Power Systems Handbook for Federal Agencies		5. Report Date April 1984 6. Performing Organization Code
7. Author(s) E. H. Cochrane, A. C. Lawson, C. H. Savage		8. Performing Organization Report N -
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16. Abstract

The Federal Photovoltaic Utilization Program (FPUP), sponsored by the Department of Energy, has provided an opportunity for 26 Federal agencies to install photovoltaic power systems in various types of applications and environments. As the cost of photovoltaic power is reduced, an increasing number of potential, terrestrial, photovoltaic applications become cost effective within these agencies. Certain Federal agencies have additional criteria for the use of photovoltaic power systems such as silent operation, reliable power, and independence from the limited availability of grid power of a host country.

The primary purpose of this handbook is to provide a tool for personnel in Federal agencies to evaluate the viability of potential photovoltaic applications. A second objective is to provide descriptions of various photovoltaic systems installed by different Federal agencies under the Federal Photovoltaic Utilization Program so that other agencies may consider similar applications. A third objective is to share lessons learned which are contained throughout the document to enable more effective procurement, design, installation, and operation of future photovoltaic systems. The intent of this publication is not to provide a complete handbook, but rather to provide a guide for Federal agency personnel with additional information incorporated by references. This handbook has been organized to present the steps to be followed in selecting, procuring, and installing a photovoltaic application. It is based on lessons learned from FPUP as well as on an overview of FPUP existing applications.

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